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APPRECIATION UNITS IN NINTH GRADE GENERAL SCIENCE

Submitted by

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CHAPTER I

Definition of the Problem

General science is a relatively new subject in the curriculum of the high schools in this country, the idea originating about the year 1899. (46, p. 33)[1] Its effective beginning, however, dates back to only about 1910 (46, p. 35), though it was not until the end of the second decade of the present century that general science was firmly established (33, p. 22), there being considerable disagreement before that time as to whether it should "remain as a standard high school subject" (33, p. 22). The rise of the junior high school stimulated its growth.

However recent may be the development of general science, we realize, after investigation, that the foundation upon which it is laid dates back to the time of Benjamin Franklin and the academy. In the latter half of the eighteenth century and the first half of the nineteenth the academy was developed out of a need expressed by Benjamin Franklin for a more practical type of education than had previously existed.

> "One of the main purposes in the founding of these academies was to establish practical courses for those who could not go to college, courses which would prepare men and women for the common walks of business, government, and every-day life." (37, p. 3)

It was to meet this need that science along with other practical subjects was introduced.

1 All numbers refer to the numbers in the Bibliography. Where two numbers occur as in this instance, the first number refers to the reference, the second number to the page.

A desire for the education of the poor as well as of the rich resulted in the rapid development of the academy and the high school. However, science had difficulty in holding to its original purpose. The colleges were slow to accept it. But when in 1872 Harvard allowed physics to count for college entrance, science became a recognized subject. The practical viewpoint of the science courses was lost after the colleges began to accept science; for in order to meet the demands of the colleges, the newly formed public high schools were forced to spend their time preparing students to meet the entrance examinations. Thus the practical nature of science was set aside and the old "fill the vessel" (33, p. 38) idea came to dominate science. It became a drill on facts.

The prosperity of our country in the early part of the twentieth century was destined to influence the so called college domination. Better financial conditions made it possible for more children to continue their education through the high school; and, as a result, these schools became flooded with students, many of whom would not go on to college. This resulted in a reaction against centering the attention upon college-entrance requirements and again the need for a practical education was felt. But the change back to an education for the masses was a gradual one and, in fact, is still in progress.

Table I shows the great influx of pupils into the public high schools at the beginning of the present century. The first column shows that in 1890 there were 56.7 percent of all the secondary school students enrolled in public high schools, but column two indicates that ten years later in 1900 there were 74.7 percent of all secondary pupils in public high schools. This is an increase of 17.9 percent over the preceding decade. Ten years later in 1910, as shown in column three, the percentage was 82.3. This is an increase of 25.6 over those enrolled in 1890. Similarly in 1920 (column four) or a decade later the percentage rose to 88.2 and in 1926 (column five) to 92.3, showing increases of 31.5 and 35.6 respectively over those enrolled in 1890 in the public high schools. This is a remarkable increase in public school dominance of the secondary field in the thirty-six years from 1890 to 1926.

TABLE I

Review of Statistics of Public High Schools 1890-1928[1] from the Biennial Survey of Education 1926-1928, Bulletin No. 16, 1930, United States Bureau of Education (6, p. 974).

Items	1890	1900	1910	1920	1926	1928
Total Population	62,622,250	75,997,687	91,972,266	105,710,620	115,050,340	120,013,000
Percent of Total Population in Secondary Schools	0.32	0.68	1.00	1.76	2.66	2.80
Percent of all Secondary Students Enrolled in Public High Schools	56.7	74.6	82.3	88.2	92.3	--

1 Excluding Statistics of Elementary Grades in Junior High School.

The attempt made by the high school to accomplish its task of educating the masses in science was disappointing. Of the science courses, Preston in his recent book says, ". . . physics and chemistry given in the later years of the high school failed to connect up their rather theoretical content with what was going on in the world outside." (63, p. 69) This failure to make science useful was evidenced in the decrease in the percentage of high school pupils enrolling in the high school science courses between the years 1890 and 1928. The data given in Table II, taken from the Biennial Survey of Education, indicate this trend.

TABLE II

Students in Certain Studies in Public High Schools since 1890, taken from the Biennial Survey of Education 1926-1928, Bulletin No. 16, 1930, United States Bureau of Education (6, p. 1057).

Subject	1890		1895		1900		1905		1910		1915		1922		1928	
	Students	Percent of Total	Students	Percent of Total	Students	Percent of Total	Students	Percent of Total	Students	Percent of Total	Students	Percent of Total	Students	Percent of Total	Students	Percent of Total
Astronomy			16,770	4.79	14,435	2.78	8,307	1.22	3,915	.53	3,224	.28	1,474	.07	1,632	.06
Physics	46,184	22.21	79,720	22.77	98,846	19.04	106,430	15.66	107,988	14.61	165,854	14.23	192,380	8.93	198,402	6.85
Chemistry	20,503	10.10	32,020	9.15	40,084	7.72	45,980	6.76	50,923	6.89	86,031	7.38	159,413	7.40	204,694	7.07
Botany									124,380	16.83	106,520	9.14	82,241	3.82	46,062	1.59

An examination of Table II shows that the percentage of high school pupils taking physics decreased from 22.21 percent in 1890 to 6.85 percent in 1928. The percentage of high school pupils taking chemistry decreased from 10.10 percent in 1890 to 7.07 percent in 1928. There were similar percentage decreases for astronomy and botany.

Not only was the enrollment in science decreasing but pupils were dropping out of school in great numbers during the first and second years of the high school course. The children were failing, therefore, to obtain "even the simplest introduction to its principles as applied daily in home and community." (63, p. 69)

In "A Study of the Colleges and High Schools in the North Central Association" in 1915 it is said, "One of the great problems confronting secondary education is that of keeping students in the high school after they have enrolled for the freshman year." (59, p. 42) A glance at the statistics given in Table III is enough to make us realize the force of the problem that confronted school authorities.

This table shows that in the United States in 1912, 41.00 percent of the students enrolled in high schools were in their first year; 27.05 percent, in their second year; 18.50 percent, in the third; and 13.45 percent, in the fourth. This shows that there were 34.03 percent fewer in the second year than in the first, 31.60 percent

fewer in the third than in the second, and 27.30 percent fewer in the fourth than in the third. It is evident that the greatest decreases are in the first and second years of the senior high school.

TABLE III

Showing Pupil Enrollment in Each of the Four Years of the Senior High Schools in the United States, 1912, taken from United States Bureau of Education Bulletin No. 6, 1915 [1] (59, p. 45)

Percent	In the United States, 1912
Percent of Students in Fourth Year	13.45
Percent of Students in Third Year	18.50
Percent of Students in Second Year	27.05
Percent of Students in First Year	41.00
Total	100.00

There was also a lack of sequence between the sciences given in the high school. The fact that they were absolutely divorced from one another led educators to feel a drastic need of a science course that would deal with science as a whole. Frank said, "There was a distinct need for some unifying course, a subject which would give the pupil a sense of continuity of the whole field of science and not an idea that Botany, Chemistry and Physics dealt with distinct and unrelated fields." (33, p. 20)

1 From a Study of the Colleges and High Schools in the North Central Association.

Thus "the tremendous growth of the high school and the cosmopolitan character of the school population which made the high school a second school for the education of the masses; . . . the formal abstract character of the special sciences and the consequent relative decrease in the enrollment in these specialized subjects that fell so short of fulfilling the possibilities of science study in a complete educational program for life in a scientific age; the low enrollment of pupils in the science courses offered during the first and second years of the four-year high school and the rapid elimination of pupils in these years, which resulted in a majority of our youth not receiving instruction in science before leaving school;" and "the lack of a sequence in science courses in the secondary school that would provide orientation and educational guidance for pupils in the field of science" together with "the changing aims of secondary education and the newer views of educational psychology," (81, 195)

have all contributed to the introduction of the general science course and to its growth so that it is at the present time an important subject in the high schools of this country, particularly the junior high schools.

It is interesting to note that the same practical view held by Benjamin Franklin, that education should be vitally connected with life, is the foundation upon which the general science courses of today are laid. With such a heritage is it not natural that the modern science teacher should consider carefully how such a view, which has survived the severe storms of the past, can be preserved? Indeed it is this that modern education is attempting to accomplish.

It is true that when general science was first introduced it was misunderstood. Hunter after an examina-

tion of early texts says,

"Leaders at this time [speaking of the period between 1910 and 1920] believed that general science was first of all valuable because it gave pre-information concerning the specific sciences of the high school, samplings which gave direction and interest in the later sciences and might possibly even aid in the vocational aspect. The earlier books gave some experimental work in laboratory and for demonstration, but were written largely from the slant and previous training of the authors and made but little use of the psychological method of attack." (46, p. 37)

The next decade showed signs of advance. Hunter points out after an investigation of studies made by Weckel, Klopp, Webb, and Davis that after 1920

"the evolution of the general science course tended toward the selection of subject matter which related to pupil activities and interests, and which was taken from the every-day environment of the pupil. During this period [1920-1930] there was a noticeable gradual emphasis on material of civic or social value, indicating that the philosophy of education for citizenship was the keynote of this decade." (46, p. 39)

In the present decade, as Powers states,

"An aim of education that seems consistent with the postulations of modern philosophy is, Life Enrichment through Participation in a Democratic Social Order. . . . The education of an individual is the effect on his whole behavior that has come from the experiences in which he has participated. A planned program of education . . . is one that provides experiences that will contribute as fully as may be to the attainment of life enrichment." (81, p. 42)

Meister in the imaginary examination of a teacher before a board of education has his candidate express the same opinion. "Effective participation in a democratic social order is the goal of education which has seemed acceptable ever since the World War." (53, p. 875)

Also Conklin in his recent article would lead us to believe that something other than the mastery of subject matter is desirable. "The true measure of education is not information but habits and character . . ."(19, p. 3) Then is this not the aim of science education?

> "Enriched living is the goal toward which science is striving, and it is the hope of science that, through tested truth, it may help to neutralize prejudice and animosity, and reduce the friction between individuals who are the entities of our human social order." (81, p. 27)

How do our general science courses fit into this plan? An examination of recent reports of committees, of investigations, and of periodicals reveals the place of general science in attempting to reach this goal. In a study (made by Clarence M. Pruitt), described by F. B. Curtis in the "Second Digest of Investigations in the Teaching of Science," it was discovered that the aims followed the cardinal principles (14, p. 11) of secondary education and also that the "Bulletin of Reorganization of Science Teaching in the Secondary Schools" (22, p. 67) had a great influence on general science aims.

The opinion of that committee in this respect is significant. It states that the teaching of science is particularly useful in the realization of six of the seven main objectives of education and the following statements show <u>some</u> of the ways in which it believes science may contribute:

Health

"It is important that those who are ill may be cured, but it is much more important that people be so taught that they may not become ill. . . . It is the duty of the secondary schools to provide such instruction for all pupils. . . . Therefore, health topics should be included in the science taught in the junior high school, and in at least the first two years of the four year high school." (67, p. 12)

Worthy Home Membership

"Science has devised many conveniences that make the modern home comfortable and attractive, and science knowledge is required for their full appreciation and most intelligent use. These activities should be definitely related to better ideals regarding modern home life." (67, p. 13)

Vocation

"Science instruction should contribute both to vocational guidance and to a broad preparation for vocation.

"In the field of vocational guidance such instruction should make many valuable contributions to a more intelligent understanding of the world's work and such an understanding should be so presented as to be of direct assistance in the wise selection of a vocation." (67, p. 13)

The committee further states that science instruction "should also impress students selecting certain vocations with the importance of making thorough and adequate preparation for their life work." (67, p. 13)

Citizenship

"The members of a democratic society need a far greater appreciation of the part which scientifically trained men and women should perform in advancing the welfare of society. Science teaching should therefore be especially valuable in the field of citizenship because of the increased respect which the citizen should obtain for the expert, and should increase his ability to select experts wisely for positions requiring expert knowledge. At the same time it should afford the basis for an intelligent evaluation of the services rendered by such experts.

"Furthermore, the study of science should give a more intelligent appreciation of the services rendered to society by those who are engaged in vocations of a scientific nature and occupations based upon applications of science. Such appreciation of the services rendered should lead to greater respect for the worker who renders the service." (67, p. 13)

Use of Leisure Time

"Science opens the door to many useful and pleasurable avocations. Photography may be taken up by many, but most intelligently by one who understands something of the nature of light, the action of lenses, the chemical changes involved in exposing, developing, and fixing plate and print." (67, p. 14)

The Committee states that if a "natural interest in these things has been developed" (67, p. 14) there will be not only "added pleasure and enjoyment" but the door will be "opened to wider interests." Especially do they stress the development of "life-long sources of enjoyment." (67, p. 14)

Ethical Character

"Science . . . should help develop sane and sound methods of thinking upon the problems of life." (67, p. 14)

Now let us consider the opinions of some of the writers concerning general science.

Pieper writing for the committee, says,

"The science courses on this level [speaking of the seventh, eighth, and ninth grades] are not to be judged primarily on the basis of their contributions to the special sciences but rather on the basis of the contributions they can make to the improvement of human adjustments in a modern environment; and second that the science courses on this level should be an integrated three-year series of courses built upon and comprehending the objectives obtained in the science work of the elementary schools." (81, p. 212)

In speaking of science in the elementary grades and junior high school,

". . . there should be throughout the first nine grades an integrated program of science that, through ever broadening experiences and activities, gradually expands the learner's abilities to understand more clearly, to enjoy more fully, to appreciate more deeply, to use more intelligently, and, so far as possible on any grade level, to adjust himself more effectively to the materials and forces of his environment." (81, p. 194)

"Finally and most important of all the measurable outcomes of science on this level are the actual behaviors — the human adjustments — performed by pupils in life situations." (81, p. 219)

"In general, science on this level should emphasize the point of view of the consumer." (81, p. 197)

Pieper indicates his agreement with Harap when he quotes the following:

"'It is recognized that pupils and laymen cannot be expected, and should not attempt, to perform certain technical activities that require specialized training, as for example, the diagnosis of and prescription for major physical ailments. In all situations involving technical problems the science instruction should lead the pupil to respect and to call for assistance from the expert.'" (81, p. 198)

In the matter of knowledges, only such information as will make adjustments more intelligent are necessary.

"In providing pupils with learning experiences through which they may gain the basic knowledges for intelligent action, it should be borne in mind that these generalizations . . . should include both the ideas developed by pure science and the social implications of these ideas. . . . It should also be planned that the generalizations become associated, as the course proceeds, into larger and larger ideas as the different aspects of the environment are considered and as newer relationships may come to light through learning." (81, p. 200)

Hunter writes,

"Science in the junior high school must open the eyes of the young people to the wonders and beauties of science all around them, not only an appreciation of science as it affects their lives at home in labor-saving

devices and hygienic protections, but also an appreciation of the wonderful things in Nature, appreciation of changes taking place about them, the forces of wind, water, heat and cold, light and darkness, and means of control over these forces." (46, p. 139)

"It is evident today that our course in junior high school science should relate itself to the many leisure time activities open to the average boy or girl interested in science.. . . The economic conditions in the future will doubtless make for a substantially shorter working day and more time for avocations. The place of science in the junior high school points primarily to adjustment of the pupil to his environment so that he may best use these leisure hours. Science can do much for him in awakening interests and making hobbies worthwhile. . . . Reading attitudes should certainly be stimulating as a useful part of this leisure time." (46, p. 143)

"The junior high school is distinctly a time for adjustment and exploration. . . . Therefore, science in those grades should do its part toward carrying out this idea." (46, p. 125)

"Lastly the factual information which is given in science is of course important. But the facts alone will not take the students far. Memory work is certainly not an end in itself. Facts must be given as a means to an end. . . . Facts must be used as a basis of further work in the senior high school, for establishing knowledges which may lead to vocations as well as avocations, and to establishing bases of understanding. But since the junior high school is distinctly an exploratory and adjusting institution, teachers should remember that factual knowledge is not its most important aim." (46, p. 145)

Cawthorne in speaking of the value of scientific knowledge says, "It is not so much utilitarian as it is cultural." (16, p. 12)

Elwell writes,

"The course in general science should be complete in itself, and as a 'unit course' be looked upon as independent of the later courses in science. General science is not a series of short independent courses in physics, chemistry, biology, physiology, and other sciences.

Only as these sciences contribute to a unified course of instruction in the practical problems of the pupil's life should they be considered." (28, p. 58)

Frank says that "exploration, guidance, adjustment, and stimulation are the dominating ideas in the junior high school science instruction." (33, p. 41)

Briggs writes,

"Relatively few secondary school students become science specialists. Even those who do, as well as all others, need an introduction simplified to suit immaturity; and as there is no guarantee that any junior high school pupil will have an advanced course in any special science, everyone should, before he is permitted to leave school, be given a preparation for his assured needs and also some understanding of the wealth of satisfactions available to him from the pursuit of higher studies." (11, p. 599)

"Although undoubtedly incomplete, this inventory discovers the objectives toward which a general science course should aim." (11, p. 600)

Briggs states that they fall under five large headings, namely, - utility, appreciation, social contact, avocation, and preparation. Preparation for the later successful study of the more specialized sciences, he states, does not "mean only that pupils should learn accurately and retain many facts and principles and that they should acquire some skill in the proper manipulation of microscope and other apparatus," (10, p. 608) but in the junior high school

"it should find and create interests, direct them until they are strong enough to persist; it should establish attitudes favorable to science and its methods; and it should reveal where satisfaction can be found, in specialized courses and elsewhere." (11, p. 608)

Quoting Turner,

"The Method [speaking of the teaching of general science] discards logical presentation of the subject matter of these sciences, but achieves continuity, sequence and scientific unity by interpreting the child's environment in terms of the child's interests, relating in order the What? the How? and the Why? Thus General Science ceases to be general information to whet the appetite of the specialist sciences, but synthetic science, the science of the environment, competent in every respect to rank equal with the other sciences." (83, p. 588)

One would gather, therefore, from the preceding statements that general science in the junior high school should not consist of miniature courses of chemistry, physics, biology, and the like. Nor should the main objective be considered as the acquisition of factual knowledge. What is wanted is a unified course that will, through the aid of science, be an interpretation of the child's environment with definite emphasis upon the development of such qualities, attitudes, ideals, interests, and appreciations as will enable the pupil to live with a greater degree of enjoyment and understanding of his environment.

The committee on the Reorganization of Science in the Secondary Schools lays much emphasis upon the place that science should take in developing desirable health attitudes, in stressing "better ideals regarding modern home life" (67, p. 13), in developing an appreciation of what science has done to "make the modern home comfortable and attractive"(67, p. 13) and in the "part which scientifically trained men and women should perform in advancing the

welfare of society." (67, p. 13) Also under the vocational objective we find mention of the part science should play in giving "a more intelligent understanding of the world's work." (67, p. 13) In the realization of the leisure time objective it ranks high the development of desirable centers of interest. In fact the committee has in mentioning the specific values of science said,

> "Each pupil of secondary school age should develop many and varied interests in the fields of science. In times past these interests came to a great extent from experiences in home life, particularly on the farm and in the village, but as life has become increasingly complex and specialized it devolves more and more upon the school to supply the opportunities for actual contact with materials that have real significance in the life of man, contacts that result in keen interests, appreciations, and powers." (67, p. 14)

Pieper gives importance to the use of science in developing appreciations. Hunter would subordinate subject matter to the development of such attitudes, appreciations, interests, and enjoyment as suggested by the committee on reorganization. And we find Cawthorne, Elwell, Frank, and Briggs recognizing as essential something other than factual information.

Attention is at the present time being directed toward appreciation objectives in science teaching. Hurd says,

> "Recently educators have begun to talk about appreciations as the most important outcomes of instruction. . . . They are commonly left to chance instruction on the assumption that they are natural concomitants of instruction in subject-matter of the conventional sort." (48, p. 124)

He, however, states in the conclusion of his study that

"certain statements involving appreciations in high-school science [including general science] are not obvious to all students of high school age. They [appreciations] need specific instructional attention in science classes." (48, p. 126)

Deyoe says that "the objective of developing an understanding and appreciation of the environment has been prominent in a large proportion of the lists of objectives for science teaching." (24, p. 97)

About one half of the objectives of teaching science given by the Committee of the State Teachers' Association of Wisconsin are devoted to appreciation, and the development of a correct attitude or interest. The following are six out of the fourteen given: (1) freedom from superstition, (2) appreciation of the contributions of science to our civilization, (3) appreciation of natural beauty, (4) appreciation of man's place in the universe, (5) appreciation of possible future developments in science, and (6) possession of interest in science. (18, p. 762)

Thus "one may acquire a ready command of the important principles of science and skill in the art of thinking, but unless he also acquires desires that impel to their use, his living must remain inefficient. Ambitions, desires, ideals, tastes, attitudes of mind - in a word, those motivating emotionalized standards that impel to worthy action - are perhaps the most important outcomes of education." (25, p. 89)

Units for the development of these emotionalized standards are too important to be left to chance. "It seems very desirable to organize units of instruction for the definite

purpose of imparting such ambitions, ideals, desires, and attitudes." (25, p. 104)

Although such conclusions have been reached, it is not to be supposed that a strict adherence to the newer aims and objectives is being observed. Conklin says,

"Our aims in teaching are too often like those of the amateur hunter or soldier who shoots into air and at things in general. . . . The ammunition is usually in the form of standardized cartridges loaded with wad from textbooks or old lecture notes." (19, p. 1)

Frank expresses his opinion thus,

"One has only to read the questions used in tests all over the country to realize that the majority of teachers of science in our high schools still emphasize recall of subject matter, rather than a real understanding of the principles involved." (33, p. 28)

Turner, an English scientist who came to this country to study the general science situation, discovered that teachers today are in some cases actually following the old type of instruction.

"Too often in the past in America — and I am afraid that this still holds true of English General Science — General Science has consisted of the more elementary and interesting portions of the more specialized sciences, Physics, Chemistry, and Biology in particular, still retained in their idea-tight compartments, a heterogeneous collection of delectable tidbits stolen from the various sciences, but still retaining the formalism of their original settings which places first the importance of the subject matter rather than that of the pupil. It would not be correct to say that this view of General Science is dead; indeed I found in some schools General Science being taught under the separate headings of nature study, heat, electricity, chemical science, sometimes even under different teachers." (83, p. 588)

"This tendency [speaking of the disconnected fragments of interesting information taught to try to popularize the subject] not only is noticeable in the classroom,

but is also evidenced by the objective tests used so much in General Science which emphasize the factual content of the subject to the detriment of the non-measurable, but nevertheless as important, outcomes of the subject." (83, p. 587)

He remarks that the textbooks are excellent, but says,

"That's the trouble. In the hands of inexperienced teachers the excellent textbook becomes a bible, never to be deviated from by a hairsbreadth, and its contents must inevitably be true." (83, p. 591)

In conclusion, correct attitudes, ideals, interests, and the development of appreciations are important outcomes of general science teaching. General science was introduced into the schools principally because of the inability of the senior high schools to subordinate the mastery of subject matter to the pupil's interests and because of the lack of unity or sequence in the sciences at that level. The main purpose of the general science courses today is not the acquisition of knowledge for its own sake but rather the interpretation of the pupil's environment so that he may live more intelligently and happily. "Knowledge must be tinged and fired with feeling to mean much in the lives of men." (20, p. 236) The appreciation technique, therefore, should be used to a large degree in the teaching of general science in the junior high school.

"The verb 'to teach' takes two objects. We teach young people; we also teach subject matter. Of the two, the young people are the more important. Our principal task is to develop a finer and better-adjusted type of young manhood and womanhood through the medium of science, not to extend science through the medium of young people." (63, p. 2)

CHAPTER II

Limitations of the Problem

The appreciation units that follow are planned for the ninth grade level. Hunter says, "Few worthwhile investigations have been made with reference to the content of general science, and none on the actual grade placement of material." (46, p. 137) But he states also that, "Apparently opinion is fairly well crystallized in the ninth year science, but wide variations occur for the other years." (46, p. 127) He summarizes the course of study from several large cities. In Chicago "the ninth grade takes up source and control of energy, reproduction in plants, and hygiene;" (46, p. 128) in New York State, "the energy concept is developed under the title 'Our environment, how we use and control it';" (46, p. 130) in Harrisburg, Pennsylvania the course is centered "around man's control of his environment"; (46, p. 130) in San Francisco, around electricity in the home, communication and transportation. (46, p. 132)

The Fifth Yearbook refers to the planning of a course in junior high school science thus:

> "For the ninth year, the dominating theme might be man's control of his environment, including in the subject-matter of instruction studies of the sources of material and energy, and the transformation and uses of both." (32, p. 150)

C. T. Hanske in an article, "General Science in Indianapolis," includes in the ninth year course of study

the scientist and his problems, germs and diseases, light in the service of man, machines and the work of the world, electricity and magnetism, communication, transportation, and the improvement of life. (40, p. 138)

Beauchamp remarks in speaking of grade placement that

"the placement and sequence of topics . . . rests upon no established principle of organization. Such a principle must take into account the complexity of the ideas presented and the intellectual maturity of the pupils at different levels." (5, p. 31)

It seems to be the opinion that ninth grade general science should utilize subject matter for the most part which deals with man's use and control of his environment, but specific selection must be controlled by the pupil's mental development, interests and environment. The material of the appreciation units which follow is selected, therefore, with these things in mind.

It is recognized that the content of the general science courses should be governed somewhat by the kind of community in which the course is to be given. Elwell says,

"For many students, this is the only science they will get. For this reason it should have to do with the life conditions affecting the pupils, and its subject-matter should be selected largely from their environment. It will, therefore, vary greatly in different communities." (28, p. 58)

Our schools find among the masses of children who attend them a large variation in ability. No attempt has

been made to adapt the appreciation units included in this thesis to the superior, dull, or mentally deficient children. The units may be enriched for the bright pupil or simplified for the slow.

The units are intended neither to be complete nor to cover the entire field of study which could be carried out in the field of appreciation for the ninth grade student. The writer realizes that there are many more possibilities than have been actually described.

Only such explanations and theories are included as will make for better appreciation and no attempt is made to force the pupil to master the information for the sake of such knowledge since it is believed that that would destroy the purpose for which the units are intended. Strayer and Norsworthy say, "Continuous and emphatic development of the intellectual may result in the atrophy of the power of appreciation in any given field either temporarily or permanently." (79, p. 129)

CHAPTER III

Appreciation Units

Foreword and Introduction to the Units

Inasmuch as the general science course should interpret the child's environment it should create a sense of unity and sequence. The series of units selected should be integrated so that the feeling of the whole is sensed by the pupils. The following paragraphs are, therefore, designed as a suggested introduction which might be presented by the teacher at the outset of the four units included in this thesis.

What an insignificant world we live in! Some of the tiny glittering points that greet our eyes in the evening sky are far greater than our sun that lights our way by day, and can it be true that the distances out there are so great that even the mile is far too small a unit of measure? Imagine, if you will, a star 215,000,000 miles in diameter — one which is large enough to cover our sun and extend out to include the orbits of Mercury, Venus, Earth, and Mars. Such is the case with the giant Betelgeuse, a sun that you may see any fall evening, for it forms the right shoulder of the mighty hunter, Orion. But even more astounding is the distance of the beautiful white star Rigel which is 540 light years. Consider for a minute what this means — 540 times 16 trillion miles. Yes, that

is its distance. Is it any wonder that you feel insignificant —yes, almost helpless — when you stand before such a vast expanse of space any evening?

But when you may chance to turn your face toward the earth and its blanket of atmosphere, are you not awed by even more mysterious things? With all the senses of your being, are you not made aware of things fully as beautiful, inspiring, and curious? The billowy white clouds that float serenely overhead made visible by the light of the moon, the flash of lightning that illumines the yet perfect evening sky, or the sound of the cricket are just as wonderful. Why look at the vast cold space only for inspiration?

Did it ever occur to you that the very substance of the clouds might at one time have been part of the ocean on which you sailed or even part of the water in the dishpan in which your mother has washed the dishes from which you have eaten; that the lightning is the same kind of power that flows into the lamps in your living-room to change night into day; or that you could no longer hear the sound of the cricket if suddenly the air around should be taken away? Yes, even the sound of our neighbor's doorbell is evidence of a mighty force possessed, not only by part of the bell when it is in operation but by the earth itself. Let us then turn our face earthward. Our world, though but a speck in this vast universe, is full of mysteries.

Illustrative Units

UNIT 1. The Weather

A blizzard, the worst in several years, is to arrive today, according to the broadcast this morning. Can it be possible that we really are to have snow this winter? A few days ago we began to think that we were destined to put our skates and skis away without using them. How does the weather man know that the storm is coming? Will he get it right? We want the snow storm because it will give us a great deal of pleasure, but there are some people to whom it means hardship. The ships at sea do not welcome storms. The captains fear high winds. Just as the weather man tells us of pleasure we may expect today, he warns people of impending disaster. To the coast he may send warnings of a hurricane or to the people who live along the rivers warning of a devastating flood.

Had you a chance to talk with the weather man, this is the story which he would probably relate. "The extent to which the work of the Weather Bureau . . . affects the daily lives of the people and becomes a factor in their various vocations and business enterprises, already very great, is increasing yearly." (86, p. 15)

Storm warnings are sent out along the coasts so that vessels are often detained in port, saving millions of dollars of cargo. To the truck gardener the weather man promises rainfall by night, to the wheat farmer in the

Dakotas a report on drought is given, to the cattleman the bureau predicts parching of grazing lands, to the banana merchant an impending hot wave is forecast, and to the mayor that the snows in the mountains are not deep enough to maintain his town's water supply. But how does it help people in large cities such as we live in? This question would not annoy the weather man in the least. He would continue: "The uses made of temperature forecasts in the cities are more varied than is usually supposed." (86, p. 15)

Notice of approaching cold waves causes greenhouses to close and boilers to be fired; preparations are made by heating and lighting plants to meet the increased demands; radiators of automobiles are drained or an anti-freeze solution added; work on concrete is delayed; and "charity organizations prepare to meet increased demands for food and fuel and thus minimize suffering among the poor." (86, p. 15)

Do you wonder why the weather man can give out such valuable information? The secret of his success, for such he has had, is not understood by most people. Certainly he doesn't guess, for it has been definitely observed that he is 80 per cent of the time correct (74, p. 366). What is his secret?

A winter with little snowfall and no winter sports will make the prophecy of a coming blizzard a source of great excitement among the children. Undoubtedly they will have been watching the weather forecasts in

the newspapers and will have listened on the radio to the predictions daily. In fact, concern about the weather and the weather forecasts will have become so real to them that there will be many questions in their minds. For this reason their inquiries are used as a basis for the work of this unit.[1]

Not only will the pupils in the ninth grade science classes be interested but also those in the entire school. It is suggested that a member of the science class, in conjunction with his work in the manual training department, make a special bulletin board with glass door and lock to be placed in one of the main corridors of the building. As the unit is developed there will be many specific pieces of work carried out by the members of the class in connection with their inquiries. Individual members or groups may wish to assume responsibility for posting on the bulletin board interesting findings concerning weather and weather forecasting. Someone may post for a period of time snapshots of various types of clouds he has taken, with interesting information concerning what they are and how they may be of use in determining weather. Another pupil may wish to show common devices, such as the flower that turns red and blue and the glass tube containing a liquid that changes from clear to cloudy with types of weather and indicate their reliability. Some may wish to devote the bulletin board for a few days to proverbs and their dependability, while still others may show something of the work of the weather bureau and reliable methods of forecasting.[1]

What are storms?

Does the fact that winds blow from the east generally before a storm mean that storms come from the east?

How does the weather man know that the wind is going to shift to the east?

When and how did direction of winds before and after storms in the North Atlantic States first become known?

It would seem that our storms must come from the east since the wind seems almost always to shift to the east before a storm arrives. I wonder if this is really true? It is a common supposition and the old Cape

1 The unquoted single spaced copy is in the nature of comment or suggestion to the teacher.

Cod folk often speak of the wild nor'easters. Was the wind east this morning? Is an east wind ushering in this blizzard? What is the weather anyway? One of the first remarks people make to their acquaintances usually concerns the weather. Nothing constitutes such a convenient way of bidding the time of day. Listen sometime to see if this is not true. "Don't you wish it would get through raining?" "It's a fine day, isn't it?" "What a scorcher!" Can't you hear them say it?

Weather is nothing more than the condition of the air ocean. But what conditions of this vast sea of air will bring about storms or fair weather?

The experiment with the convection box shown in figure 209 on page 212 in "Practical Physics" by Black and Davis and experiment 77 on page 300 in "First Principles of Physics" by Fuller, Brownlee, and Baker are suggested as possible demonstrations in connection with the work of this part of the unit.

"The best model of how the continents make weather is a burning house. The flames go upward in a great column of fire and smoke, not downward to spread out on the ground; a familiar fact but one which holds the chief weather clue. Hot air is lighter than cold air. The fire heats the surrounding air and it rises, just as the old-fashioned hot-air balloons used to rise at country fairs carrying aloft the aeronaut and his parachute.

"A continent heated by the sun's rays acts like a gigantic fire. It warms the air above it. This air tends to rise. When the continent cools off at night the air above it cools too. Then this air tends to sink; precisely as the hot-air balloon comes down when its filling of heated air has cooled. Similar motions are generated by sunlight in the earth's oceans; the surface water being heated by the sun's rays in one part of the earth and left cooler in others. Thus are created great

rising and falling motions in the ocean and in the atmosphere. . . ." (34, p. 17)

If sawdust is placed in a kettle of boiling water we can observe the particles rising and falling. This motion shows us how the water in the kettle is moving as it becomes heated.

"Were it possible to watch the earth from some outside point of vantage as one watches a teakettle, and were balloons scattered through the air to serve as markers of the currents, all the gigantic circulation of the atmosphere could be seen precisely as one sees the water move in a kettle on the stove. But that is denied man except in imagination. He is like a tiny animalcule creeping on the bottom of a teakettle." (34, p. 18)

But the making of the earth's weather is not quite so simple as it may seem. The unequal heating of the air and the surface contour of the earth serve to break up this larger circulation of air into smaller whirlpools or eddies.

The children may wish to know something about the ability of various substances to absorb and radiate the energy from the sun. The diagram on page 131 in "Problems in General Science" by Hunter and Whitman suggests a demonstration that will be helpful. Also see "Everyday Problems in Science" by Pieper and Beauchamp, pages 98 - 102. Someone in the class may be curious about the radiometer and may wish to investigate it. Very sensitive thermoelectric detectors have been made so that they may respond to the heat radiated by a candle a mile away, the heat radiated by a star in the sky, or the heat radiated by the engines of hostile bombing planes. (7, p. 222)

Why is a black road always hotter than a white cement walk?

"During the day the sun's radiant energy does not warm the air at the same rate over the water surface as over the land, and on land the rate is not the same in

a valley as it is over the hilltops, nor over a forested area as it is over fields or over sandy plains. The different rates are chiefly due to the variations in surface absorption and radiation and in the moisture content of the air in the various localities." (8, p. 5)

The whirlpools or eddies which result are caused by the air over one portion of the earth becoming heated more than in other parts. Why does smoke from a chimney fall toward the ground before a storm? The air over the earth absorbs moisture from the ground and becomes so light that it is easily forced up by the surrounding cold air on all sides of it. The cold air moving downward and in under the warm air carries smoke with it. This is a true indication of a storm. Because the earth is rotating the air does not move straight into these sections but is diverted in such a way as to cause a spiral motion which is counter-clockwise in the northern hemisphere and clockwise in the southern hemisphere. This motion of the air is called wind. The warm moist air that rises may, if holding enough moisture, become cooled enough when it reaches higher altitudes for the moisture to condense and cause rain or snow, depending upon the temperature. Such an area as has been described would be called a storm area or cyclone. These may bring storms of varying intensity, depending to some extent upon the degree to which the air has been heated and the amount of moisture collected. If there are sections where the air is rushing in

there must be sections where the air is moving out in all directions, allowing more air to move downward and eventually push outward. These would be the fair weather areas or anticyclones.

And so the same laws that cause the air in your rooms at home to circulate or the water in your teakettle to become heated are operating to help produce weather. Then "the fundamental cause of weather changes is the gigantic engine of the boiling atmosphere, driven by the heat of the sun." (34, p. 18)

A group of students may wish to examine the weather maps printed by the Weather Bureau. If they can observe the maps for consecutive days, they may detect the storm movements. Weather maps may be obtained daily from the Weather Bureau in Boston at the small cost of twenty cents a month.

From day to day there is a march of these storm and fair weather areas across the United States. The weather man calls a storm area a "low" because the air in its center is warm, moist, and therefore light. This causes it to have little or low pressure. Just the opposite is true of a fair weather area or "high." On a weather map one can follow these "lows" and "highs" as they move. It can be observed that their movement is generally from west to east. Men who have studied weather for many years have discovered that storms originate generally in one of three sections of the United States, the northwest, south, or southeast. (90, p. 472) Most of our storms, however, come from the

northwest, move a little to the southeast and finally reach the Great Lakes region. (90, p. 472) "From there they travel northeast and leave the continent by the valley of the St. Lawrence River." (82, p. 102)

Figures 1, 2, 3, and 4 on pages 33 and 34 demonstrate the movement of a storm area across the country. The first position of the storm in the west near the Canadian border (Figure 1) shifts southeast (Figure 2) then northeastward to an area north of the Great Lakes region (Figure 3) and finally moves out over the Atlantic coast (Figure 4).

A wooden or cardboard model of a storm area may be made by the children. This may show the movement of the air into the low. If this is then placed on the map and moved it may easily be shown that an east wind will usher in a storm.

But we must not think that these storms will always travel along a well defined path. Although that is their general path, they vary greatly from any well defined course. Their speed also varies. As these storm areas move from the northwest to us, the eastern side of them will strike us first. Since the air is rushing in from all sides, that on the side of the storm area that reaches us first will be blowing from the east. As the storm passes away from us we are on the other side of the "low" and the wind will be rushing in from the westerly direction. The way the wind shifts tells us much about the part of the storm area that is striking us first and from what general direction it must be coming. Benjamin Franklin contributed to man's knowledge of storms.

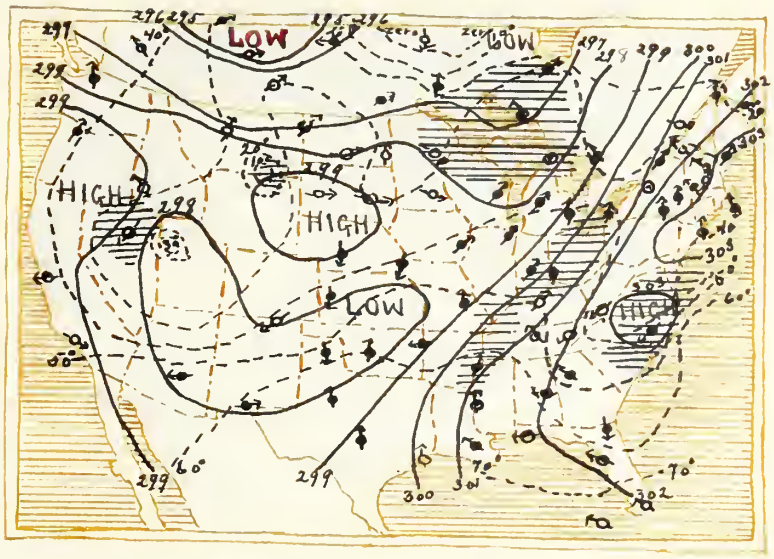

Fig. 1. Weather map for March 19[1]

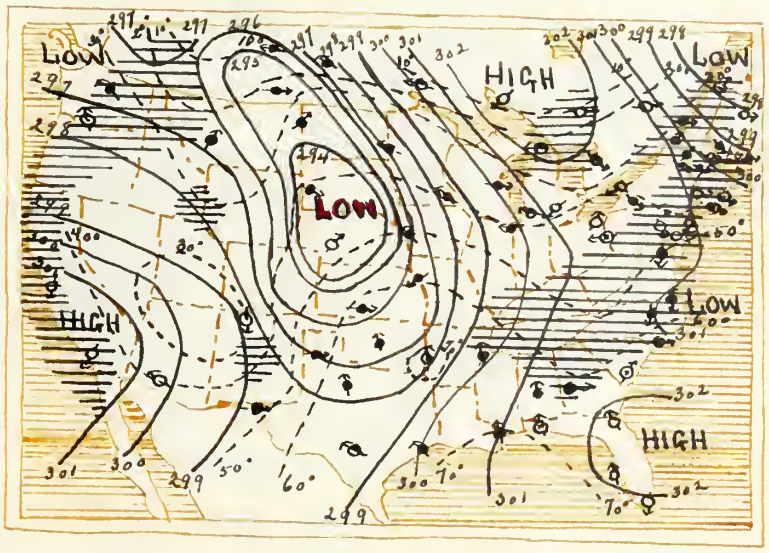

Fig. 2. Weather map for March 20[1]

1 See Appendix for original map of which this is a copy.

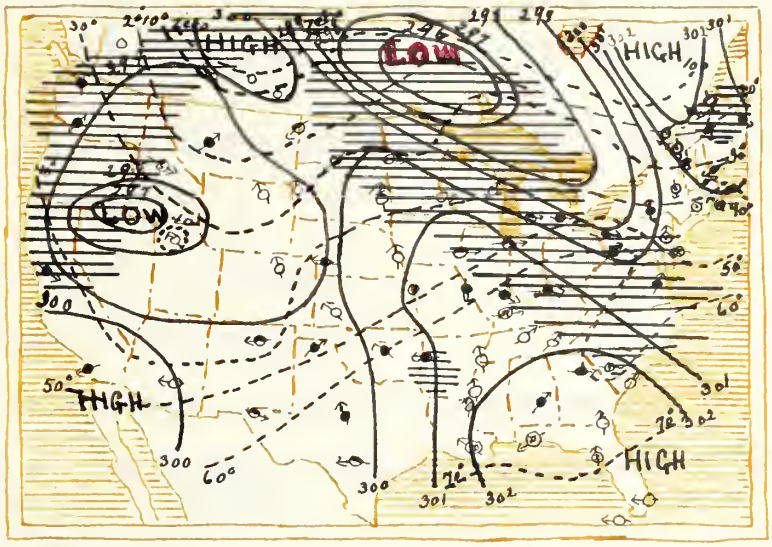

Fig. 3. Weather map for March 21[1]

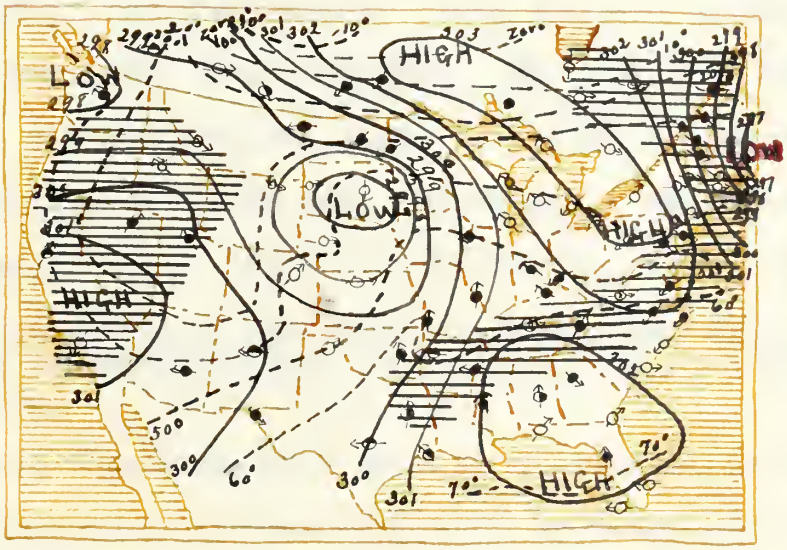

Fig. 4. Weather map for March 22[1]

1 See Appendix for original map of which this is a copy.

"In 1747, while taking observations at Philadelphia of a lunar eclipse, in cooperation with his brother at Boston, he learned that storms moving from the west, as all storms of the middle latitudes do, first begin with easterly winds, and as they approach a place of observation become westerly, and he came near discovering the cyclonic system of storms." (31, p. 74)

So we may tell our Cape Cod friends that their nor'easters come from the west.

What is a barometer?

What is its purpose?

How can one indicate the weather?

What instruments are used in weather forecasting and why are they needed?

You have an instrument at home that has the words "fair," "change," "rain," and "very dry" printed across its face, but its reading does not always correspond with the kind of weather existing. Why is it so often wrong? What is the name of the instrument? Yes, it is a barometer but how can a barometer tell weather? What does it really measure? You are not the first to wonder why this instrument apparently fails to tell the truth. Your barometer is the aneroid type, but this was not the first type made.

The story of the first barometer and experiment from which it developed may be investigated by a member of the class.

The reason we have such an instrument is the result of an accidental discovery made by a man who lived years ago. The Duke of Tuscany had bought and installed a new pump but found that he could not raise the water from

his well with it. He called upon Galileo, a great scientist of his day, to help him out. Galileo suspected that the air might not have enough pressure to force the water up from a well fifty feet deep. He sought the aid of his brilliant pupil Torricelli who through a famous experiment proved that the air did not have enough pressure to force the water up in his pump more than 32 feet. Torricelli's experiment developed into an instrument which we today call the barometer.

The students will be interested to know that the same experiment can actually be performed in the classroom. See experiment 26, page 95, in "First Principles of Physics" by Fuller, Brownlee, and Baker.

This is called the mercurial barometer. Today there are several types used, the Kew and Fortin. The one we have in our school is the latter.

One of the pupils can investigate how this type works, how it is read, and how Pascal discovered that air pressure decreases with altitude. Suggest that one of the pupils keep a record of the barometer readings and weather conditions for a week or so.

The screw at the bottom of the Fortin type must be adjusted "in order to raise the mercury in the reservoir so as just to touch an ivory point which is fixed to the ceiling of the cistern and serves as the zero of the barometer." (31, p. 126)

After Torricelli's experiment became known Pascal stated that the pressure of the atmosphere must be less on top of a mountain.

"Pascal tested his theory by carrying a Torricellian tube to the top of a high tower in Paris, and then asked his brother-in-law to repeat the experiment on the Puy De Dome, which had an elevation of over three thousand feet. It was found that the column of mercury was nearly eight centimeters shorter on the mountain top than in Paris." (36, pp. 98, 99)

The range of the scale found in the modern barometer depends upon where it is to be used. At sea level the variation would be 31.1 to 27.3 inches. A barometer to be used in a mine will have the upper limit increased while one used in mountainous regions will have a much lower limit. The Fortin type barometers usually are not made to read lower than 20 inches unless they are specifically designed for use in mountaineering or high altitude surveying. (31, p. 127)

Some in the class may want to find out how the aneroid barometer works.

The aneroid barometer, the kind that you have in your home, is a much later development than the mercurial type. These barometers are more delicate and easily put out of order and are not so accurate but are convenient and easy to handle. The weather man uses recording instruments of this type.

But what has the barometer to do with the weather? In a storm area the air is warm and moist and is continually rising because cooler air is pushing it up. As the storm approaches one would, as a result, expect the barometer to fall and when fair weather is arriving he would expect

the barometer to rise. Thus to say that the barometer reads between 29.5 inches and 29.7 inches would mean nothing. Yet that is what the names on your barometer are attempting to do. It is a rising or falling barometer that indicates a storm or fair weather.

You noticed in the newspaper that the weather man also records humidity, temperature, wind direction, wind velocity and precipitation. How can he measure these?

A student may assume the responsibility of finding out what instruments are used by the weather man for these purposes. Someone else may investigate the operation of the instruments. They may even be interested in the history of some, such as the thermometer. In conjunction with their work in the manual training department they can make a weather-vane, hygrometer, and rain gauge. A group of brighter pupils can collect and set up weather instruments to use in their own forecasting laboratory.

Reliable instruments are extremely valuable in the forecasting game. The thermometer which measures the temperature of the air; the hygrometer, telling humidity; the wind vane, indicating wind direction; and the anemometer measuring wind velocity are all important to the weather man. We are not so familiar with the rain gauge as we are with the thermometer and other instruments. It looks very much like a complicated milk can and is constructed so that "the open top of the gauge is ten times the area of the measuring cylinder. [This means that 1/10 of an inch of rainfall gives a depth of one inch in the cylinder.] The amount of rainfall is measured in inches and fractions of an inch by a scale on the cylinder which shows how deep

the water in the bucket is." (65, p. 101)

We are more familiar with weather-vanes than we are with the rain gauge. Can you read a weather-vane? Does the arrow point in the direction from which the wind is coming, or does it point in the direction the wind is blowing? Deacon Shem Drowne, an eighteenth century coppersmith, must have known the secret of the weather-vane for he made the glass-eyed grasshopper we can see on Faneuil Hall in Boston. There are two others of his making, the revenge cock which gave the "Cockerel Church" its nickname and the "Province House Indian," and newly discovered papers and bills show that the "Old North Vane" is also his handiwork. (3, p. 6)

One of the pupils who was interested enough to make a weather-vane may demonstrate to the class how it is made and how it works. The pupil may wish to read to read about the ancient weather-vanes. See Porter's Rambles in Old Boston.

Day in and day out the weather man observes his instruments which represent the best way man has of knowing what is going on in the ocean above his head. The unvarying laws that cause the storm areas to form show clearly that the temperature will rise, the barometer will fall, the humidity will increase and because our storms usually come from the west, the wind will generally blow from the easterly quarter. It is wonderful to think how these laws of nature work. Air that is warm is light. Warm air holds great quantities of moisture. Cold air is

heavy and falls, pushing the warm air up. A combination of these conditions causes a low pressure area. And these factors are determiners of weather. But we must not think that man understands all of the laws governing the air eddies that we call storms. He has still much to learn.

Man is now concerned with the conditions of the atmosphere at greater heights above the earth for he has learned that they can give him a clue to the coming weather. He, therefore, carries instruments such as the barometer, thermometer, and others in airplanes to heights above the earth. If you live in Boston or one of the suburbs you may have heard such an airplane circling overhead in the early morning. The results of these observations can be found in a section of the daily weather map called "upper air observations."

"During recent years, particularly the last two or three, marked progress has been made, both in the United States and in various European countries, in the development of what is known about the radiometeorograph. This is an instrument consisting of a radio transmitter which is actuated by an aneroid barometer, a bi-metallic thermometer, and a hair hygrometer - all of extremely light weight but of high precision. The apparatus is suspended from a small rubber balloon filled with hydrogen, which ascends at the rate of 600 to 800 feet per minute and reaches heights sometimes as great as 15 miles or more. During the ascent signals are sent to the recording station, where they are converted into actual values. . . ." (38)

The development of this instrument will be a great aid in exploring the upper air. Reports from instruments sent up in airplanes cannot be received for

some time after the observations have been made, but they may be known immediately by the radiometeorograph. This, in time, may help man to make more accurate forecasts.

How is a weather map made?

How does the weather man forecast storms?

Are there other reliable ways of forecasting?

A series of four specimen weather maps is included in the appendix. They are for consecutive days and show the progress of a storm from the northwest to the eastern coast.

How did the weather man know where the blizzard was, so that he could determine how soon it would reach us? Yes, it does seem almost miraculous that he could tell. He cannot ascend in an airplane far enough to look down on our country and see these storms travelling. Neither does he guess. The weather man gets all the facts that he can about the atmosphere and then places them on a map so that he may see them together and translate them. Were you to visit a weather bureau you would see him - yes, not only one but many men - at work gathering information concerning our air ocean.

Let the children examine a weather map to discover what information the weather man gathers.

The weather map is really a summary of his findings. Look at one for a minute. Yes, the air pressures, represented by the isobars or solid lines that pass through places that have the same barometer readings; the temperatures, represented by the isotherms or broken lines passing

through places of the same readings; wind direction; and all that he can find out about air conditions are recorded. Thus he knows the areas of low pressure. But how does he know what the air pressure is in Florida? So important is it to know what kind of weather to expect that our government has established weather stations all over the United States. There are about two hundred of them scattered throughout the United States and the West Indies. (30, p. 132) The observers at these stations twice daily at 8 a.m. and 8 p.m., 75th meridian time, take observations of air pressure, temperature, precipitation, direction of the wind, state of the weather, current wind velocity, clouds, and maximum and minimum temperatures since last observations. (86, p. 3) Besides these two hundred smaller weather stations, there are five central stations to which the various states report. Massachusetts reports to Washington, D.C. For the forty minutes following 8 a.m. and 8 p.m. the observations made by the observers are speeding on their way to the central weather station in Washington. The information is condensed into a telegraphic cipher message so that information comprising about 30 to 50 words is reduced to 4 or 5 words. "The telegraphic circuits are so arranged that at any station those reports are taken off that are used in making charts and forecasts at that station." (30, p. 133) By means of these messages it is possible for maps to be constructed

showing the weather conditions all over the country. Then the weather man has the advantage. It is as if he were standing on an eminence overlooking the entire country. He has a complete picture of all the existing storm and fair weather areas. He watches the storm movements from day to day, anticipates the changes that take place in them, and the territory they cover. In that way he was able to tell us that the blizzard was coming. The weather man cannot make forecasts for more than 12 hours in advance, however, for local indications are usually not heralded much more than this number of hours in advance.(8, p. 27) So you see, the weather man does not guess. He gathers definite information on which to base his forecasts.

The information is valued not only by you and me but also by the mariners who watch the storm warnings displayed for their benefit. What signals does the weather bureau use? Have you ever seen any of them displayed?

Someone will undoubtedly like to make a set of flags and other signals used to warn ships of approaching storms. The flag indicating the weather for the day may be posted in the school room or on the bulletin board, if the pupil decides to use the bulletin board for a few days for weather flags and signals.

Why is the aviator so concerned with the weather? Does the weather forecast mean anything to the photographer, manufacturing companies, physicians? How has the radio helped in forecasting?

The new weather map in three dimensions which will be of particular value to the airplane pilot will be of interest to some member of the class. It can show meteorological conditions to an altitude of 16,000 feet and is, therefore, helpful in plotting the upper air weather conditions as "obtained by pilot balloons, army airplane flights, and the weather data supplied by airline pilots." (72, p. 36)

Let the pupils choose which they will investigate. Some may even wish to consult various business people in their own locality to discover whether they depend upon weather forecasts. Outdoor painters, amusement and awning companies as well as candy makers use forecasts to a great extent. Much information along these lines can be found in a publication of the United States Department of Agriculture called "The Weather Bureau." The children themselves may send for this information. The price is only five cents.

It is surprising the number of people who watch the forecasts. Have you ever noticed that store-keepers usually display goods appropriate to the weather? On a day of a coming snow storm you will see sometimes a window full of snow shovels or it is not unusual to find stores displaying rubbers and raincoats when rainy weather is forecast. And the interesting part about it is that their displays are usually ready in good season.

People have always had concern for the weather. "The cave man, no doubt, scanned the sky carefully each morning, grunted his satisfaction or muttered some primordial oath and formulated his plans for the day on what his observations revealed." (38) His more intelligent successor came to see "relationships between signs of the sky and other things that they saw" to the weather. Probably that is where our weather proverbs or sayings have come from.

Some of them are good signs. How many of these would you believe? "To see the old moon in the arms of the new one is reckoned a sign of fine weather; and so is the turning up of the horns of the new moon. In this position it is supposed to retain the water which is imagined to be in it." (80, p. 182) "When cats sneeze it is a sign of rain." (80, p. 230) "When dogs eat grass it will rain." (80, p. 231) "When crickets chirp unusually, rain is expected." (80, p. 254) "Salt increases in weight before a shower." (80, p. 267) "Sounds are heard with unusual clearness before a storm." (80, p. 268)

"Evening red and morning grey,
Help the traveller on his way:
Evening grey and morning red,
Bring down rain upon his head." (80, p. 181)

Weather proverbs and signs always have fascinated people and some of them are used today as ready means of doing their own forecasting. A member of the class will undoubtedly want to make a collection of these weather sayings and attempt to determine their validity. Some may even wish to see how some of them work out. (8, p. 27)

Are the flower that turns red or blue and the glass tube containing a liquid that turns clear or cloudy with weather changes accurate forecasters?

A pupil may examine some cobalt chloride, heat it and note its color, then add water and observe the change. See page 586, "First Principles of Chemistry" by Fuller, Brownlee, and Baker. Someone else may discover by testing a liquid that it may hold more solid in solution when heated than when cool. (34, p. 113) A sample of each type might be made and its action observed by the class.

They are interesting devices but they are not to be depended upon. The former is really a hygrometer, for it is the moisture in the air that changes the color from blue to red while the latter is a thermometer, since it is the temperature of the liquid that causes a solid to either be held in solution or not. (34, p. 113)

Clouds are to some people better forecasters. What did the clouds you saw from the school room window yesterday look like? Can sea captains really tell the kind of weather by the clouds? In olden days ship captains and other persons spent much time observing the formation and movements of clouds. There really was no other way for them to predict the weather. The weather man today even records them in his records.

As we lie out in the fields in the summer we can the clouds change their form. We may imagine we see a beautiful mansion such as those in the stories we have read or a king in all his pomp. But suddenly our mansion disintegrates and becomes an old tumbled down shack and the pompous king changes to a snowy mountain. Finally, right before our eyes it spreads out and a part of it disappears. What are the clouds and whither do they go?

Have you had the experience of riding in an airplane above the clouds or of standing on the top of Mt. Washington where the clouds seem to float about you?

Those are wonderful experiences but we do not have to go to the top of Mt. Washington. Many a foggy day you have walked through a cloud near the earth.

The demonstration suggested on pages 28 and 30 in "General Science for Today" by Watkins and Bedell may be useful here.

Yes, is it not peculiar to think that the sun's heat evaporates the water from the ponds, lakes, rivers, the ground and damp leaves of plants, that the air which is also heated absorbs it, becomes light and is pushed up by the cooler surrounding air to heights where it expands and becomes cool, and that the cooling condenses this moisture into droplets so tiny that the rising columns of air hold them in space? We look up at this mass of water droplets and this we call a cloud. As more condensation takes place, the droplets become larger and rain falls. Is it possible that the rain or even the snow that may fall next week may once have been a part of some river, pond, or lake?

Were it possible for us to examine a raindrop carefully, we might find a tiny dust particle. It is strange to think that if air was absolutely pure and clean, there would be less condensation and therefore less rainfall. Just as the moisture in the air on a hot day in summer does not condense until it touches a cold pipe or water pitcher, so the moisture in the air above the earth does not condense until it touches a dust particle or something else that may act as a nucleus.

"The tiny particles in the air which are to provide condensing places for the moisture are not all of them ordinary dust. Many of them are smaller motes technically called ions. An ion is an electrified atom or a group of electrified atoms.

"The atmosphere is filled with these ions, with ordinary dust particles and with other minute things. There may be as many as fifty or a hundred thousand of these particles in a cubic inch of air. And these particles whether ions, dust, crystals of sea salt, or what-not, are the cores, centers, or nuclei around which the moisture in the air condenses to form droplets of water." (34, p. 28)

Rain does not fall from all clouds either because the layer of air has not risen high enough to cause enough cooling and hence enough condensation to take place, or because there was not enough moisture in the beginning.

Why do some clouds look black? Do they contain smoke? Most people think so. They are black because they are holding much condensed water vapor. One has often noticed that the deeper a body of water the darker it looks. The water of the Saguenay River in Canada is black because it is so deep.

In places, it is thought to be a mile and a half in depth.

"A very dark cloud is already raining; a white cloud, in the Indian's phrase, is rain - not yet." (34, p. 33)

There may be some in the class who will want to take pictures of the various clouds and find out what kind of weather they indicate. Others may wish to study snow crystals and the formation of sleet and hail.

White billowy clouds that look like fluffy balls

of cotton are fair weather clouds and are of the cumulus type. The rapid upward motion of hot moist air may cause these peaceful clouds to assume a "dark, threatening appearance" and become a terrifying thunderhead. (15, pp. 104 and 106)

"Contrasted with the cumulus clouds are the fleecy, feathery clouds that are often observed high in the sky. They are the highest of all clouds, sometimes floating five or six miles above the earth and usually not nearer than three or four miles. Their height places them in a region of very cold air. Hence they consist of ice crystals. These cirrus clouds are always the advance guard of a storm. They travel with rapidly moving air currents, sometimes nearly one hundred miles an hour, and so reach us before the lower slow-moving clouds.

"As the heralded storm draws near, the shape of the cirrus clouds may change to low lying stratus (layer) clouds. The stratus clouds become the nimbus (storm) clouds. The nimbus cloud is the rain cloud, hangs low in the sky and is wide in extent. The stratus clouds are most often seen at sunrise or sunset just above the horizon." (90, p. 106)

Can it be possible that a howling blizzard on a day in February, a frightful thunder storm in July, a beautiful day in June are all results of the condition of the seemingly harmless ocean of air that surrounds us on all sides? An ever restless sea this is - ever moving but never without reason. By the heat of the sun the movements of the air are controlled. Thus the weather man has learned that in the operating of nature's unvariable laws is held the secret of the coming weather. We cannot make weather; we cannot foretell the coming storm by

merely guessing, for such is not the plan of our universe. Are not law and order its design?

This unit should develop an appreciation of the "universal operation of natural laws (cause and effect relationship)." It is hoped that it may also develop such attitudes and appreciations as "freedom from ignorant practices," freedom from superstition, and appreciation for the wonders of nature.

Films:[1]

Eastman Classroom Films:

1. "Atmospheric Pressure"
2. "Weather Forecasting"
3. "The Water Cycle"

Supplementary Reading List:[1]

1. Bliss, G. S. - Weather Forecasting with Introductory Note on Atmospherics (Fifth Edition), United States Department of Agriculture Weather Bureau Bulletin No. 42, 1929. Washington: Government Printing Office. (For ten cents this pamphlet together with Number 4 in this list and a chart of cloud formations, a weather map and explanation may be obtained from the Weather Bureau in Washington.)

2. Free, E. E. and Hoke, T. - Weather. Practical, Dramatic, and Spectacular Facts About a Little Studied Subject. New York: Robert M. McBride and Company, 1928.

3. Meister, M. - Living in a World of Science. Water and Air. New York: Charles Scribner's Sons, 1930. (Chap. IX, pp. 117-130)

4. (The) Weather Bureau. Compiled by E. B. Calvert, United States Department of Agriculture. Miscellaneous Publication No. 114. Washington: July, 1931.

1 This list is merely suggestive of enriching material. It is not intended to be complete.

UNIT II. Our Control of Magnetism and How We Use Magnets.

When you were on your trip to New York did you ride in the subway trains? Did you stand on the front platform "looking out into the dusky darkness? It is one of the many thrilling experiences in a great city. As you stand there with face pressed against the glass window, you somehow feel the tremendous power of the 300,000 pounds of steel as it hurtles through black space at a speed of sixty miles an hour. To your right is a little cubbyhole of a room in which sits the motorman. His hand controls the speeding monster and to his judgment is left the safety of ten car-loads of human beings.

"You can ride for hundreds of miles under a great city. Six millions of people crowded together in a small area need special ways of moving about, particularly if they want to move quickly." (52, p. 120)

What makes this system of transportation possible? Had you been able to examine this speeding monster, you would have found a device that was working for you as you speed through the subway tunnel. Yes, it was an electric motor and this is not its only service. Think for a minute what this machine means to you and me. It

"has become an essential to modern existence. . . . To start an automobile you operate an electric motor. In the modern home you will find vacuum cleaners, electric fans, washing machines, dish washers, sewing machines, phonographs, massage machines, electric driers, and refrigerators all

driven by motors. The wonderful electric signs which attract your attention perform their tricks with spinning motors. Escalators and hoists, derricks and cranes, printing presses and linotypes, grindstones and polishers, lathes and drills, stamping machines and cloth cutters, pumps and presses - all depend on the electric motor for their usefulness." (52, p. 122)

But where do these electric motors come from? We take these marvellous servants for granted. We have always accepted the service which they render. Stop to think just what such devices represent. Yes, the hard work of hands and minds. Not only one but many dauntless pioneers spent years of experimenting in order to give us the electric motor that not only lightens the burden of household drudgery but gives us pleasure.

Even our friends of ancient times speak to us through the electric motor for hidden in the innermost parts is found a magic power. They first found it in the world about them, misunderstood and misused. Today because man understands it, he is able to produce it artificially and put it to work. What is it?

It is suggested that the unit be integrated by an activity in which the whole class can participate. The students may prepare a class book on the subject of "The Electric Motor's Ancestry." Each of the pupils may select as the work proceeds a part that he is most interested to investigate. The pages should be made large enough and only one side used so that they can be posted in the room or elsewhere for exhibition purposes after the completion of the book. The material both illustrative and otherwise will be collected by the students. The following pages suggest the material which may thus be brought to the attention of the pupils and suggest possible ways in which it may be handled.

How do electric motors help us in the work we do?

How do these practical servants use the motor? Does it serve the same purpose in the electric fan as in the vacuum cleaner? in the hand drier as in the refrigerator? (52, p. 129) The motor in the vacuum cleaner operates a fan that pumps air into the dust bag, thus producing a vacuum in the chamber around the fan. This causes air to rush into the machine, carrying the dust with it. (61, p. 484) The motor in our electric refrigerator drives a pump that carries the gaseous refrigerant from the cooling coils in the refrigerator box and compresses it in other coils outside the box. (85, pp. 322 and 323)

The pupils may choose the device that they will be most interested to investigate. The girls will be more interested in household devices, such as dish washers and sewing machines, while the boys will choose the escalator, hoist, derrick, and the like.

What parts of our electric motors do the work?

What is an electromagnet?

Where do electromagnets do work?

Why can some electromagnets lift heavy weights?

A very mysterious workman this machine may seem to be. How can electricity make it spin around? Is there some hidden secret?

Let the pupils examine a toy motor which will reveal two essential parts.

A large piece of soft iron is wound round and round with fine wire and its shape is such that it seems to

enclose another part (a coil) that rotates rapidly when the motor is in operation. "In modern motors, this soft iron core forms almost a complete shell, so that very little of the inside is visible." (52, p. 125) The coil that is found inside of the shell "is made up of a large number of turns of wire, in bundles, around a soft iron drum which carries a shaft at its centre." (52, p. 125)

These are the essential yet secret parts of an electric motor. But what are they? How do they work? When the motor is spinning, it is surprising to find that a piece of metal such as a pen-point or pin when held near the piece of soft iron wound with wire, will be drawn out of our hands as if by some unseen force and, once in contact, remain there until the motor stops running. This magic power, for such it seems, is produced by a magnet. In fact it was the interest of a man by the name of Tom Davenport, a village blacksmith at Brandon, Vermont, in magnets that resulted in the first patent of an electric motor. (52, p. 122)

One of the children will wish to read the interesting story of this blacksmith and prepare a resumé for the class book.

But this magnet is very different from the one with which you are familiar. You have undoubtedly played magnetic jackstraws, but there were no coils on the magnet used.

The class may visit a scrap iron yard or factory where large quantities of iron and steel are handled to see a huge electromagnet in operation. Some of the students may assume special responsibility for discovering, through observing and asking questions, how much the magnet itself weighs, the largest weight it will pick up, how the magnet is made to lose and gain power, and how much the skull-cracker weighs if one is used in the place visited.

Electromagnets "are used to lift kegs of nails, to load iron on cars, to handle steel in steel plants and shipyards, and to do many kinds of work of a like nature." (50, p. 18) In some factories they use what is called a skull-cracker. "It lifts a ball of iron 12,000 pounds in weight, then drops it on metal castings so as to break them into small pieces. These pieces are then ready for the furnace, where they are melted for further use." (52, p. 3) "Warships that were discarded in accordance with the Washington Disarmament Treaty were taken to Alexandria, Virginia." (76, p. 558) Here they were destroyed by the use of such a skull-cracker as is described above. A great steel ball weighing at least a ton or more was lifted 75 feet by an electromagnet. The current was then turned off and the ball allowed to fall on the hull, crushing it. Iron rods the weight of which total 3,000 pounds may be loaded into cars by huge electromagnets with nothing needed to bind them together. They save time and labor "that would otherwise be required to surround these objects with chains while the crane does the lifting." (36, p. 554) What powerful servants man has made! It is hard to imagine

that some of these giants can handle a load of 16,000 pounds.

Upon return to the classroom some of the pupils may be curious enough to make an electromagnet. The demonstration found on pages 25 and 26 in "Science Related to Life," Books III and IV, by Reh, is suggested; also that described on page 14 in "Everyday Electricity" by Lunt. These will arouse further curiosity and reveal that when electricity passes through a wire a magnetic field is set up around it. Of course, winding the wire into a coil in which is placed a soft iron core increases its strength. The story of Oersted's discovery and Joseph Henry's work in using this principle to produce what we know today as an electromagnet may be read by some of the members of the class. The students will also be surprised to discover that they can increase the strength of an electromagnet by increasing the strength of current used and the number of turns of wire around the core. See demonstrations on page 26, Book III, in "Science Related to Life," Books III and IV, by Reh.

The electric bell and the telegraph use the electromagnet because it can be made to lose and gain power at will. In fact, it was Joseph Henry's exhibition of his sensational electromagnets that would lift huge weights that led Samuel F. B. Morse to invent the telegraph. Morse, who was really a painter and sculptor, was returning home from Europe when he fell into conversation with a Dr. Jackson about the electromagnet, a much discussed topic of the day. It was at this time that Morse thought of the idea of the telegraph. (52, p. 32)

Can magnets pick up everything?

What difference does this make in their usefulness?

What were the first magnets ever known to man?

How did the ancients feel about this strange power?

Why could the doctor remove the steel from Jack's eye? Why do not doctors always use magnets to remove dirt from people's eyes? Is electricity used to operate the magnet that your father used to move the index in the maximum and minimum thermometer that he has in his greenhouse? Where do magnets like that get their power?

Pupils may test samples of iron, brass, silver, steel, nickel, lead, copper, rubber, paper, and other material to discover the magnetic and non-magnetic substances.

"The most important magnetic substances are the various forms of iron and steel and alloys of iron and nickel. Practical uses of magnetism are confined to these." (36, p. 525) Both the metal cobalt and the gas oxygen with which we are all familiar have some magnetic properties. (57, pp. 20 and 552) Our jack straws then must be made of a magnetic substance and only magnetic materials can be removed from a person's eye with a magnet. Iron workers may have a more healthful environment in which to work because iron dust may be removed from the air with magnets. A weather observer may keep a record of the maximum and minimum temperatures because a magnet does not attract mercury, but it will attract the index and move it because it is made of a magnetic material.

Magnets which possess magnetism without the use of electricity do seem very mysterious.

Soft and hard iron or steel cores may be placed alternately in the coil of an electromagnet. The students

will be surprised to discover that the hard iron or steel cores remain magnets while the soft iron core loses all power.

The magnets used in moving the index of a maximum and minimum thermometer are made by placing a piece of hard iron or steel inside of a coil through which electricity is passing. After the steel is removed it holds its magnetism. Thus it is a permanent magnet. There are, however, magnets that man has not made. In "The Arabian Nights," a shepherd when passing through a field chanced to drop his crook. (36, p. 552) When he attempted to pick it up he found that the iron tip was held firmly to a dark colored rock. This is only one of the stories told of a curious brown stone that had a pulling power like the giants that do heavy work for man. The shepherd in the story may have been the first one to discover it, but no one really knows. It is believed that the Greeks found great quantities of it near Magnesia in Asia Minor. (7, p. 281) In the writings of the ancient Greeks, Hebrews, and Romans there is mention of the magnet as a "lodestone," which is another name for this rock. (52, p. 1) For as mysterious as this brown stone may seem, it can be found in Norway, Sweden, and parts of our own country today. (7, p. 281)

An opportunity is presented here for someone to make a map showing the places where this stone called magnetic iron ore or magnetite is found today.

Another story found in the Third Calendar of "The Arabian Nights" depicts a people whose understanding

of such phenomena was very meager. These ancients were superstitious. Can you imagine a person today believing in such a story as this? One day a ship drifted down toward a huge mountain of lodestone. The power was so great that the nails were drawn from the ship to the extent that the ship fell apart. In fact it was impossible for ships to pass this mountain, because the attraction from the lodestone was so great.

These were probably the first magnets ever known but today man has learned to try things out and test their behavior so that he is no longer superstitious about them. He understands to the extent that he has learned to produce the same kind of force artificially. In fact, we can magnetize a piece of steel by merely stroking it with a magnet.

What influence do magnets have upon one another?

How has man made use of this influence?

How uncanny is the advertising device (brought in by a member of the class) called a "Mystic Oracle" which answers questions as if by magic! It appears to be merely a cardboard folder inside of which is a disc with questions arranged around it. But in some mysterious way it seems to be able to answer questions like a magician. Investigation shows that if the dial is placed with the question pointing to an arrow and the folder closed, a metal hand on the outside will point to the correct answer.

Some of the questions asked are based upon science, and the accuracy with which the "Mystic Oracle" answers them is amazing to the pupils. This advertisement of the one-time Reynolds' Shingle Company may not be obtainable now, but similar practical uses of the magnet probably are.

Why did not the magnet from which you magnetized pieces of steel lose some of its power?

The ancients had they had the "Mystic Oracle" set before them would certainly have thought it magic but it is nothing more than the action of two magnets. The piece of steel on the outside and the concealed piece on the inside can be shown actually to pick up small bits of soft iron. These are magnets themselves. Why does the pointer always point to the correct answer?

A demonstration on page 14, Part III in "Science Related to Life, Books III and IV," by Reh, showing that all magnets have places in which their power seems to be greatest will be useful.

Magnets have regions of power, called poles, that are located in a bar or horseshoe magnet on or near the ends of the magnet. But magnets also have places of little or no power called the equator. This portion of a bar magnet is the center of the magnet. The poles are marked north and south. An electromagnet may be tested and also found to have poles.

The students are always very much interested to discover by experiment the law of magnets. See "Science in Daily Life," by Trafton and Smith, page 120, demonstration 4, part (a), and "Science Related to Life, Books III and IV," by Reh, page 28 of Part III, and part 2 of the demonstration suggested.

It is strange to think that in the "Mystic Oracle" the like poles repel each other while the unlike poles attract one another so that the point of the arrow always points to the correct answer. Repulsion and not attraction is really the true test of magnetism, since a magnet may attract any piece of steel or iron whether it is a magnet or not.

The students may test unmarked magnets to identify the poles.

Commercial concerns use this law of magnets to help them advertise but did you ever stop to think that the spinning of the electric motor in your refrigerator was made possible by this same law?

The pupils may discover through demonstration how the poles of an electromagnet will be affected by reversing the current. A model, the St. Louis type, should be put at their disposal.

But how is this all accomplished? It seems very strange that a change in the direction of the electric current can change the poles of an electromagnet but without this effect our motors would not run. Watch the model motor spin. As the armature turns, the brushes come into contact with different segments of the commutator. This sends the current in the opposite direction, thus reversing the poles of the electromagnet. The operation of the law of magnets then keeps the armature spinning. But this is a simple motor. Some of those that propel the subway trains, and operate the pump in your refrigerator have a commutator

divided into many more segments and there are many more bundles of wire on the armature. (52, p. 125)

Some in the group may attempt to make an electric motor.

Just why magnets have poles and why magnets do not lose their power when other magnets are made from them have not yet been definitely proved, but it is believed that this power results from the arrangement of the tiny particles or molecules of a substance, which are believed to be themselves tiny magnets having poles just like a larger magnet. Thus

> "when the north pole of a magnet is brought near a piece of iron, the molecules swing around so that their south poles are pointing toward the north pole of the magnet. Magnetizing a body, then, consists in turning the molecular magnets so that their north poles point in the same direction. At one end of a magnet, north molecular poles will make the outside layer, and this will be a north pole; at the other end, there will be a south pole for a corresponding reason. . . . Careful measurements have shown a slight increase in length when a bar is magnetized." (36, p. 527)

Scientists once, with very delicate apparatus, broadcast over the radio the sound of these molecules turning around as the core of an electromagnet was magnetized. (82, p. 121)

Someone may be interested to find out what Sidney J. French has discovered about polar molecules.

Sidney J. French asserts that the action of polar molecules, it is thought, explains why gasoline will not mix with water, why kerosene mixes more freely with gasoline than with water, and why salt and sugar disappear in water

with the stir of a spoon while sulphur, iodine, or moth-balls merely settle to the bottom.

"As a man in the dark may paint a mental picture of an object by feeling its contours, so scientists have pictured the tiny invisible molecules by feeling their 'contours' with all sorts of electrical feeling devices. The result is a new science of molecular structure.

"Molecules of water, for example, are now thought to be constructed like tiny magnets having a positive electrical charge at one end and an opposite or negative charge at the other end." (35, p. 24)

Why does the compass that the boy scout uses point always in the same direction and why does it not point directly to the north star? It does seem strange that a compass needle always swings around into the same position.

Nothing is more convincing than for the group or member of the class to make a compass. See demonstration in "Science Related to Life, Books III and IV" by Reh, page 17, Part III.

Yes, the compass needle is a magnet but it seems even more mysterious than the "Mystic Oracle" because there seems to be no second magnet present. The truth is that there <u>is</u> another magnet. But where is it? Queer as it may seem, we are actually living on a huge magnet. An Englishman by the name of Gilbert proved this back in the sixteenth century.

A member of the class may wish to find out how Gilbert really discovered it. (7, p. 284)

Imagine a magnet about 8,000 miles in diameter with poles just like any other! Can it be possible that the

same force that operates our electric motors is possessed by the earth itself? Then the same peculiar law of repulsion and attraction must be operating. It does seem confusing when we realize that the north pole of our compass needle points north.

"According to the naming we have adopted for compass poles, the earth's pole in the Northern Hemisphere must be an S-pole, and that in the Southern Hemisphere an N-pole, but they are not so named." (36, p. 538)

But where is the earth's north magnetic pole?

Some of the students may want to make a map showing the positions of the north and south magnetic poles of the earth in relation to the geographical poles. Others, likewise, may wish to make a map showing the parts of the United States in which the compass will point true north. This will lead to their determining the magnetic declination for their part of the country.

Columbus discovered that the needle of the compass did not always point true north.

"When Columbus left Portugal, he noticed that his compass needle pointed west of true north. . . . When he had passed the Azores Islands, his compass pointed due north, and for the rest of his voyage it pointed east of true north. Columbus kept a record of these changes; but to his sailors they were a source of great uneasiness; for they thought that the very laws of nature had changed in these strange seas." (42, p. 238)

The north magnetic pole shifts from time to time. It has been known to make small changes daily from hour to hour.

"At times, great and irregular changes in the earth's magnetism take place, causing compass needles to swing irregularly from their normal position. These are called magnetic storms. From the fact that magnetic storms usually occur when great disturbances called sun spots are observed in the atmosphere of the sun, it is thought that the sun in some way is the cause of the

earth's magnetism. The sun spots are in turn thought by some to be associated with magnetic conditions of the planets." (36, pp. 541 and 542)

Because of the constant changes in the magnetism of our earth, there are careful determinations of declination being carried on by the various governments of the world. Their findings are recorded on maps and charts for the use of navigators and surveyors. Without this information the direction as told by the compass would be misleading. (36, p. 539)

To keep accurate these navigation charts it is necessary to make exact compass determinations periodically. Because "ordinary ships, even wooden ones, contain so much iron that they disturb the delicate instruments and falsify their readings," it is difficult to obtain accurate compass readings at sea. For this reason Great Britain in 1935 was planning to build a new non-magnetic ship "to replace the lost Carnegie, formerly operated as a cruising laboratory by the Carnegie Institution of Washington. The Carnegie was destroyed by explosion and fire while refueling in the harbor of Apia, Samoa, November 29, 1929." (70, p. 92) In this yacht all iron and steel fittings and machinery were replaced with bronze and other non-ferrous metals. The only iron in the internal combustion engines was the lining of the cylinders. Even the iron of the "tin" cans was of concern to the "scientific command."

Ships today are employing a compass which is not affected by the iron of the ships because it is not dependent upon magnetism. This is called the gyroscopic compass. Do you know what kind of a compass the aviator uses? This, called an earth inductor compass, does not operate like the one used by the mariner.

A member of the class may wish to investigate how these work. See Encyclopedia for detailed explanation.

If the earth's north magnetic pole is so far away, how can it affect the compass? Did you say that your scissors had become magnetized in a mysterious way? Why did your magnet lose some of its power when you dropped it?

Some of the children will be interested in a demonstration that will show the field of power about a magnet and the effect of one magnetic field upon another. Also they may test materials such as iron, nickel, zinc, copper, and others to determine what substances the lines of force will pass through.

Magnets have a field of power about them that may extend out to a great distance if the magnet is strong.

"Non-magnetic substances, such as wood, paper, copper, and aluminum, do not deflect the lines of force. . . . Cardboard screens . . . do not in any way affect the direction or number of the lines of force from the magnet." (36, p. 535)

Only materials which are attracted by a magnet deflect the lines of force. The earth is such a huge magnet its lines of force extend out for miles around it and the walls of our building cannot keep them out.

The work of Michael Faraday in relation to the field about magnets is significant and might be investigated by

some member of the class. Someone else may be interested in the story entitled "The Haunted Restaurant" in "Popular Research Narratives" collected by the Engineering Foundation, p. 16.

Proof of this is taking place around us for not only is the compass needle affected but ships built of steel plates have been known to become magnets. Pillars supporting elevated railroads have become magnetized. "Steel umbrella rods, vertical steel pipes, girders, and machine tools are usually found to be permanent magnets, as a result of the inductive effect of the earth's magnetism." (36, p. 538)

The experiment suggested on page 537 of "First Principles of Physics" by Fuller, Brownlee, and Baker would be a useful one to help the pupils discover the inductive effect of the lines of force of the earth. Also by placing a magnetized nail in such a position that it points east and west and hammering it or heating it, the children may see that it loses its magnetism.

When steel objects are placed in a position so that the lines of force of the earth can pass through them, the north poles of the tiny molecules are attracted. When the object is jarred, the molecules line up, thus magnetizing it. This is probably what happened to your scissors.

Hidden in the inner recesses of an electric motor are two important workmen. They are the result of man's hand and mind and hours of experimentation. But hundreds of years ago the ancient Greeks found in a brown rock a similar magic force. Years passed before anyone understood it. Gilbert proved that the earth acted as a single piece of this stone. Oersted and Joseph Henry showed man how he

could produce this same power artificially. Michael Faraday explained much about magnets by studying the region surrounding them. And so today the physician, the weather man, the housewife, and industry use the same wonderful force that held the ancients in the grip of fear and superstition. The whirr of the vacuum cleaner, the sound of the doorbell, the spinning of the electric fan, and the singing of the electric sewing machine all bespeak of a force now understood and put to work by man. The electric motor is probably the most important result of man's efforts along this line.

This unit should present to the students an appreciation of man's control of the forces about him because of his increased understanding. It is hoped that minor attitudes and appreciations, such as freedom from fears and superstitions, appreciation of the wonders underlying our commonplace environment and appreciation of the work of great scientists will also be developed.

Films:[1]

Eastman Classroom Films:

1. "Magnetic Effect of Electricity"

Supplementary Reading List and Books for Home Experimentation:[1]

1. Clark, C. R. and Small, S. A.- The Boy's Book of Physics - A Simple Explanation of Modern Science with Easily Made Apparatus and Many Simple Experiments. New York: E. P. Dutton and Company, 1922.

(Chap. XII, pp. 207-217
Chap. XIII, pp. 234-238)

2. Collins, A. F. - The Boy's Book of Experiments. New York: Thomas Y. Crowell Company, 1927.

(Chap. III, pp. 52-76
Chap. IV, pp. 77-92
Chap. VIII, pp. 150-164
Chap. IX, pp. 173-183)

3. Lunt, J. R. - Everyday Electricity. New York: Macmillan Company, 1927.

(Chap. II, pp. 5-19
Chap. XIV, pp. 161-180)

4. Meister, M. - Magnetism and Electricity. New York: Charles Scribner's Sons, 1929.

(Chap. I, pp. 1-19
Chap. II, pp. 20-30
Chap. III, pp. 31-42
Chap. XI, pp. 120-130)

5. Morgan, A. P. - A First Electrical Book for Boys. New York: Charles Scribner's Sons, 1935.

(Chap. II, pp. 24-38
Chap. IV, pp. 52-64)

1 This list is merely suggestive of enriching material available. It is not intended to be complete.

6. Morgan, A. P. - The Boy Electrician - Practical Plans for Electrical Apparatus for Work and Play with an Explanation of the Principles of Everyday Electricity. Revised Edition. Boston: Lothrop, Lee, and Shepard Company, 1929.

(Chap. I, pp. 1-15
Chap. V, pp. 82-91)

7. Parker, B. M. - The Book of Electricity. Boston: Houghton Mifflin Company, 1928.

(Pp. 88-122
pp. 123-137)

UNIT III. Our Magic Genie - Electricity.

"When we think of the heroes in the stories we have read, there is one who excites our envy more than any other, - Aladdin and his wonderful lamp! With his lamp Aladdin could do what he wished. He rubbed - and his faithful servant appeared to obey his commands. We envy him because we, too, should like to have such power; and though we do not take the story too seriously, it fascinates us and permits us for a little while to indulge our fancy.

"Today we do not have to dream to find ourselves masters of a wonderful servant. At any moment we, too, can rub a kind of Aladdin's lamp - only we call it 'pressing a button.' We press - and lo! - a genie appears. Or rather, the electricity flows; and, like the genie, it accomplishes many wonderful things." (52, p. 73)

What is electricity?

Perhaps of all the marvels in the world, electricity is the most astonishing. When the sky blackens and the lightning streaks through the nightlike sky to be followed by a deafening crash, we are smitten with fear. But this same kind of terror-striking force can be controlled by you and me. When we push the button on the wall, pick up the telephone receiver, push a button that rings someone's door-bell, or turn the knob of our radio we command it to serve us.

What uses has man made of electricity for his benefit?

What are some of the ways this power works for us when we get it? Did man many years ago do things in cruder ways because he didn't understand electricity? Were there some things he did not have or could not do because he did not know how to make this genie work for him? What are some of the ways electricity is made to do work?

The students may wish to investigate some of these things. An illustrated booklet may be prepared by each pupil in which he shows how electricity does much that man used to do in the earlier stages of his civilization. Each pupil may choose the one that he is most interested in to investigate. Some may choose lighting, some cooking, some washing. Perhaps the latter part of the booklet can be devoted to showing some of the things that electricity does that could not have been done by man in early times.

Yes, when our magic genie appears, what uses we do make of him - to light our bicycles, our houses, and our automobiles, to send photos over the wire, to cook our food, to run sewing machines, and to assist in operating the automobiles or buses which transport us to school, to operate the traffic signals, to help in printing the books we read, and even to wash our clothes!

How is electricity harnessed for work?

How is it produced in steady flow?

But where does the electricity that comes into our homes to operate our toasters, sewing machines, and the like come from? Can man produce this useful servant? How does he do it?

Take the pupils on a trip to a generating station. The L Street station in Boston or the Edgar station in Weymouth, both Edison stations, are most convenient to those in the suburbs. Most of the districts in and around Boston are served by the Edison Electric Illuminating Company. It is assumed that the L Street station in Boston is the one visited because it is more easily reached. Give the children a list of things for which to look. What machines produce the electricity, what are the essential parts of this machine, why does an electric company need a large quantity of coal, and how much coal does it use? These are a few of the things the children may look for and discover through asking questions.

What a huge affair is an electric generating station that supplies us with electricity! Over 150 men work to help keep the L Street plant in Boston running smoothly and this does not include those that repair the huge furnaces, boilers, and other necessary equipment. Eleven monster machines produce electricity at this plant. The number operating, of course, depends upon the load needed. Together they can produce 198,000 kilowatts[1] of electricity per hour. Yes, these huge machines that produce electricity contain electromagnets, built within them. These great magnets are the hearts of the machines. How would Joseph Henry[2] feel if he could look at these monsters helping to make electricity with electromagnets far larger than any of which he dreamed? But how do they do it?

Let the students observe the result of passing an ordinary magnet through a coil of wire, the ends of which are attached to a galvanometer.

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1 This figure is quoted from the L Street station, Boston.

2 Joseph Henry benefiting from Oersted's discovery completed some of the first experiments to show that a coil of wire concentrated the magnetic strength inside of the coil. Through these simple beginnings the electromagnet developed.

Can you picture a young scientist in an old-fashioned laboratory pushing a magnet through a coil of copper wire and discovering that a current of electricity is produced? What a wonderful discovery it was! When a current is produced this way the tiny lines of force around the magnet are cut across by the wire. Then results an "induced" current of electricity in the wire. In our experiment we cannot get much current. How can we increase the power? Yes, we can move the magnet faster in the coil of wire. This cuts more lines of force per second and the current becomes stronger proportionately. Now unwind half of the coil. The needle of your galvanometer does not swing so far. Less current is generated. Use a stronger magnet and thrust it in and out. The needle swings farther. So the huge generators that produce electricity must have (1) many loops of wire, (2) very strong electromagnets, and (3) the magnets and coils of wire must be moved rapidly with reference to each other. (50, pp. 76 and 77)

A model generator put at the pupils' disposal will make clear the use of the slip rings and brushes in generators where the coils are revolved. In the type of generator seen at the L Street station the slip rings are necessary only where the direct current is led to the electromagnets. It may be brought to the attention of the students that in some generators the field revolves and the armature coils are stationary while in others the opposite is true. In most commercial generators, however, the armature coils are on a stationary frame and the field revolves.

Then what would we have seen had we been able to look into one of the huge generators?

A student may wish to make a large diagram showing the internal construction of a dynamo and thus present to the class the complexity of the dynamos used in the power house. For example, one of the vertical type generators at the L Street station has 10 pole pieces; the horizontal type has 2 pole pieces. The coils are made up of many flat strips of copper 3/4 of an inch in width and 1/4 of an inch thick and are insulated from each other. There are in the vertical type dynamos 720[1] revolutions per minute while in the horizontal type there are 3,600[1] revolutions per minute. Many lines of force which are sent out by the powerful electromagnets are thus cut across first in one direction and then in the other by the coils in the stationary stator.

What moves the magnets inside of the coil? Yes, the huge steam boilers furnish all the necessary power. The steam is used to operate the huge turbines which in turn make the magnets revolve inside of the coils of wire.

A member of the class may wish to investigate how a steam turbine operates.

No wonder the generating station needs coal - yes, great quantities of it. Imagine using over 700[1] tons of coal in one day. Of course, the amount used depends upon the season of the year. In the winter more current is needed and, therefore, more generators must be operated. Have you ever seen a fire before as hot as 2,500[1] degrees Fahrenheit?

You did not see any men handling the coal at the station. Is it not wonderful that this is done automatically? The coal is unloaded from the boats, that dock beside the plant, by means of big steam-driven buckets that deposit it in the storing field. Similar buckets carry the coal when needed to the upper part of the station and dump it into the

1 Figure quoted from L Street station in Boston.

bins, from which it passes through the chutes to the furnaces. The stokers, as our guide told us, are the mechanical men that push the coal into the fire box. Did you notice how immaculate everything was? No coal dust filled the air nor did it cover the walls and floor.

But what is going to happen if man continues to use such quantities of coal to make fires to turn water into steam which is the power that turns the turbines which turn the dynamos to produce electricity?

"Though there seems to be plenty of copper in the world for the wires and coils needed, and though we can find plenty of iron for magnets, the demand for power to turn the coils in the presence of magnets [or to rotate the field] is rapidly exhausting the supply of fuel. Until very recently the chief fuels used in power plants were coal, oil, and gasoline. We are told by geologists that a day will come when there will be no more coal and no more oil. What shall we do then?" (52, pp. 78 and 79)

A possible source of power to replace steam is "water power," or the work that can be done by falling water when properly harnessed. Man has been letting this great source of power go to waste. It is possible for a water turbine to play the same function as the steam turbine. This is the plan used at Niagara Falls.

"Some of the water from the river above the falls is diverted and caused to fall through vertical pipes, or penstocks, to the level of the river below the falls - a distance of more than 200 feet. At the bottom of the huge penstocks are placed water turbines, whose blades are revolved by the force of the falling water." (36, p. 704)

Niagara Falls is a natural waterfall but the same result can often be attained by the building of a dam, which gives

a "head" of water with its potential power.

Boulder dam is an example of water being harnessed to produce power for electricity. Someone may wish to find out more about this man-made source of water power.

What do the abbreviations "A. C." and "D. C." so often seen on an electrical device mean? Why do our electric clocks keep accurate time? The current that came from the generators in the power station that we visited was an alternating current because it flowed first in one direction and then in the opposite direction. In the dynamos that we saw, the current alternated 60 times every second in one direction and 60 times per second in the opposite direction. This means that there are 60 cycles per second.

Let the pupils observe the action of an alternating current generator. This will help them to realize why the current alternates. Lunt suggests the use of the Miller-Cowen Dynamo electric machine. (50, pp. 79 and 80)

The movements in the tiny motor in the electric clock you have at home are timed to the alternation of the electric lighting current from the generators. Did you realize that there were two clocks in the operating room of the power plant - one electric and the other mechanical, but both elements within the same casing? The black hand on the face of the clock is connected with the movement of the mechanical clock while the red one is connected to those of the electric clock and hence to the generator. The mechanical clock, regulated daily by radio messages received from Washington, D.C., is kept in perfect time.

If the operator notices that the two hands are not together he sees that the speed of the dynamos are regulated so that there are always the same number of alternations every second. Our electric clocks are, therefore, right unless something happens to break the current.

The abbreviation D. C. indicates direct current. Some industries, such as electroplating companies, need direct current. Storage batteries are charged with direct current. Alternating current can be transmitted longer distances with less expense. A common direct current generator is not much different from an alternating current generator.

It may be possible that a member of the class may wish to find out the one essential way in which the D. C. generator differs from the alternating current dynamos. A model direct current generator may reveal to him that a commutator divided into segments is used in place of the slip rings of the A. C. dynamo and that this causes the current to flow in one direction.

In D. C. generators the field or stator is stationary and the armature or rotor revolves.

Are there differences in the responses of substances to electricity?

If so, how can this knowledge be utilized?

What are the good conductors, the non-conductors?

When you were in the bus room of the power plant you undoubtedly noticed the gloves orderly arranged ready for use. What are they made of and why are they made of this material? Would not any material do just as well?

Probably you have noticed that you can take hold of the electric cords in your home without fear of getting a shock and that you do not need to fear to touch a push button. But if you touch the inside of an electric light socket into which the bulb is screwed, the result is not pleasant. What is the material in the socket? Some substances apparently hold the electricity back while others allow it to pass through easily.

The pupils will be interested to know the difference between a conductor and a non-conductor. An experiment in which various materials are tested, by placing them in a bell circuit, can be carried out by the pupils themselves. From this they may come to realize not only which substances are good conductors and insulators but also that an electric current must have a complete circuit in order to do work. The pupils may wish to find out some of the materials that are used in their homes because they do not carry electricity. They will discover that silk, cotton, porcelain, glass, rubber, and many other substances are used around their house and even other places to insulate against electricity.

Rubber gloves cannot carry or conduct the current, thus they protect men who find it necessary to work around electric wires.

What effect does an electric current have upon the conductor through which it flows?

How is this effect increased or decreased?

How does man make use of it?

What did the guide mean when he spoke of the heat produced in electric wires? Yes, electricity can help to create heat. Sometimes this heat may prove disastrous and other times beneficial. Our magic genie can make the

coils in the toaster hot or he can heat the coils in our electric iron. He can even do our cooking for us. But how can he do it?

The girls will be particularly eager to know how the heat in a permanent wave machine is produced. This involves the resistance offered by conductors of electricity. The teacher may wish to demonstrate, therefore, the difference that the kind of material and the diameter and length of the wire have upon the heat generated and the children will take great pleasure in investigating the ways in which man has made use of this knowledge. It is most interesting and surprising to note the control which man has gained over electricity so that it can aid him in his work. Some of the pupils may find out some of the general rules and special provisions for electrically heated appliances. (1, pp. 180 and 182)

The conductors used to carry the electricity from one part of the station to another and to us must be of the correct size. Large wires and cables must be employed when more current is to be carried so that little heat will be produced.

What is an electric circuit?

How can electricity be controlled by people in their homes?

What are some of the commercial uses man has made of electricity because of his knowledge of how to interrupt an electric circuit?

What dangers can exist in handling electricity?

How do switches control the electricity in the power house? Why is it necessary to open and close them in oil? We ourselves command this powerful servant to do as we wish by pushing a button on the wall, by pulling a cord, or even by inserting a device to make our Christmas

lights go off and on. How can we control it?

The pupils can now gather from electrical stores and from other sources (they may even have some old ones at home) all kinds of switches or other devices that are used to control the electric current. They will probably find the push button, the double throw switch, the wall switch, the tumbler switch, and others. Let them examine those that they are most interested to examine. Some may have certain kinds of controls at home and would therefore wish to find out how they operate. Most simple circuit-breakers can be taken apart easily; and by connecting them to an electric bell and cell, the pupils can observe what happens when the button is turned or the switch thrown. They are always very much delighted to discover for themselves that it is only a matter of bringing together or forcing apart two conductors that enables them to command this power to do as they bid.

It seems strange but it is true that our servant will not flow through the wire until there is a complete path or circuit. The circuit-breakers break the road so that the electricity cannot flow.

This is what the man in the power house does when he operates switches. But what did you see when you brought together the two pieces of metal thus making the circuit? Yes, the current really jumps the gap and makes a spark which the electrician calls an electric arc. But what would be the size of the spark if by chance a huge current was travelling between the two parts? You can imagine what would result. If electricity of high voltage (such as would come from one of the generators) jumped a gap when the switch was thrown so much heat would be generated that the switch would probably be burned out and the man killed. For this reason the man in the operating room

operates from his switchboard a motor that in turn opens or closes the switches to which the generators are connected. These switches are placed under oil incased in insulated tanks so that there is less danger. Thus the generators may be shut on or off as the power is needed. So dangerous is the controlling of electricity of high voltage that the oil switches controlling these high voltage currents are placed out of doors. What a tremendous force man is controlling! Electric arcs may cause trouble in our homes.

"Wires loosely connected in a socket can form an arc. If the ends of the wires are not twisted around and out of the way, they may come close enough together to form an arc. Two bare wires should never be twisted about each other and then taped. Each wire should be taped separately if the wires must go side by side. The danger from contact of broken or loose wires is great. For this reason there is always danger in an extension light because the constant moving of the light may wear off the insulation and cause an arc, or the connections may become loose." (90, pp. 300 and 301)

You have some circuit-breakers in your home that are of a great deal of value to the members of your household. Have you ever looked in the fuse box in your house? Neatly screwed into sockets are the valuable controllers of our magic power, electricity. Have you ever heard of people using coins instead of fuses (the name of these little circuit-breakers)? Is it legal? What is the purpose of the fuse?

Children are often familiar with the habit of inserting a penny instead of a new fuse and think it

economical. Occasionally a fire which has been caused by such a practice occurs in a community. It will, therefore, be of real profit for them to find out that a fuse serves as a circuit-breaker and safety device. This offers an excellent opportunity for the teacher to show the proper use of it and also the dangers of short circuits. Here the hazards of running lamp cords under rugs can be shown. Why the law demands that an electrician have a license to do wiring also can be introduced. This should impress upon their minds the need of handling electricity in ways to secure safety and is also an excellent opportunity to instill respect for the expert.

A group of students may investigate the various ways that fuses are used in a school building. Here they will discover that fuses are of different types and that a fuse must not be able to carry too much current. Necessarily, fuses that are made to carry more current will be used in the main fuse box.

Pupils who have observed the wire photos in the newspapers will want to know how the picture is produced. They will be particularly interested when they realize that one type of photo-electric cell which makes this wonderful feat possible is a device which makes and breaks the current of electricity and is dependent upon the action of light upon such substances as potassium, selenium and caesium.

What can cause doors to open as if by magic when one approaches them and what makes talking pictures possible? Another marvel of our day and a definite indication that man has gained control of electricity is the invention and use of the photoelectric cell or electric eye as it is sometimes called. The photoelectric cell has also been of much use in preventing burglary. There is

"a device which, as the intruder gropes through the darkened room and before he has even touched the apparatus, will detect his presence and then automatically set off a siren, send a warning signal to the police, turn on the lights, take a photograph of the burglar and give him a dose of tear gas.

"Another device widely used in Europe acts not only for burglars but also for fires. Automatically it dials the police station or fire department, as the emergency requires; dials the home of the proprietor of the property; dials the supervisor of the telephone exchange as an added check. Then in a clear unexcited voice, the robot tells what is wrong.

"These two types of mechanical watchmen depend on the photoelectric cell - that weird 'electric eye' which, my means of invisible infra red rays, 'sees in the dark.' The 'unexcited human voice' emanates from a phonograph record." (75, p. 94)

Certainly the students will want to discover how this cell can accomplish all of these things.

Children who are familiar with many accidents resulting from people touching electric wires sometimes wonder why they do not get shocks when they take hold of the two terminals of a dry cell. Certainly they need to understand that they must keep this magic power in its place.

We do not need to fear electricity from a dry cell, for 1.5 volts is not enough to make one even conscious of its presence. The body is not a very good conductor since the skin resists the current to some extent. We do need to fear high voltage currents, however, for if electricity of high enough voltage is allowed to flow through some part of our body, it can do us harm. Many times people are injured by touching an electric wire because they make themselves part of the high voltage circuit.

How is the electricity transmitted from the generating station to our homes?

Why is it necessary to have huge transformers outside of the generating station? What are they and what do

they do? Those huge machines certainly did look imposing. Larger still were they than the generators we saw inside the building. You may have used a similar machine with a toy electric train. Connected with your doorbell, if it is an electric one, is probably a device very similar. Have you seen the queer looking black boxes on the poles that carry electric wires? These, too, are devices similar to those in the yard of the power station. But what do they do?

To the bus bars (heavy copper bars) to which the generators are indirectly connected by oil switches, the cables which lead out of the station are connected. Thence current travels out to the various cities and towns. The Edison Electric Illuminating Company serves about 600 square miles of territory. If electricity is to be transmitted long distances (as is sometimes the case), the voltage must be stepped up. But why is this so?

"There is only a certain amount of energy in any electric current. Some of the energy is used as current, and some as pressure. The amount of current (number of amperes) multiplied by the amount of pressure (number of volts) equals the amount of energy (number of watts). By increasing the voltage of a current, the current can be cut down, and yet the same amount of energy kept. Thus, current is generally carried between towns and from the power plant under high pressure (voltage) and the energy does not change into heat." (82, p. 139)

The huge machines you saw in the yard are called transformers and are for the purpose of stepping up the voltage. The voltage at the L Street station is stepped

up to 25,000 volts. But before it enters homes it must be stepped down. "We cannot use high-voltage currents in our homes because, as you know, high voltage is dangerous. The voltage must be reduced, and the amount of current increased." (82, p. 139) The voltage is stepped up and down many times along its route depending upon the distance it must be carried and to what consumer it is to be distributed. In many cities and towns there are substations housing huge transformers that do this work.

There must of necessity be two kinds of transformers - step up and step down transformers. How do they do their work and how do they differ? What kind of transformer is used for your electric bell? What kind did you use for your toy train?

Curiosity will lead some to inquire how these transformers work. The demonstration suggested on pages 110 and 112 in "Everyday Electricity" by Lunt will be helpful. Thus the pupils may see that the action of the transformer also depends upon cutting the lines of force in the field of a magnet and that the relation of the number of coils in the secondary coil to those in the primary coil determines whether the current will be stepped up or down.

How does the power company sell you electricity?

The pupils will undoubtedly want to know that their fathers are paying for electric power when they pay their electric bills. They will be interested to know how they can figure the cost of using certain electrical appliances in their home.

How did man produce electricity before he used the dynamo?

Do we still use this method?

We get most of our electricity from the huge generators about which we have been talking but they do not supply the electricity for your bicycle. How do miners down deep in the earth light their way? Where does this electricity come from? Where does the electricity that lights the lights, supplies the spark that ignites the gas, or manipulates the horn on our automobiles come from? Yes, electric cells and batteries furnish the necessary power for some things. We do not stop to think that the use of the dynamo is fairly recent. Man used electric cells to obtain electricity long before he had the dynamo. The generator, however, because it can furnish such huge quantities of electric power,has made many more conveniences and comforts possible. But if we had lived about one hundred years ago we would not have been able to have electricity from any of these sources for man has come to have control of this force since that time. But how does a cell produce electricity?

In conjunction with this, the story of Galvani's experiences with the frog legs and Volta's use of Galvani's discoveries in making the first electric cell are significant. The students may even want to find the name of the place where Galvani lived and where Volta tried out his experiments and to locate these places on a map.

Current electricity, the kind that we can use, was first made by a man named Volta. We use or read his name many times for whenever we see a sign that says

1,000 volts or 500 volts we are honoring his name. (52, p. 45) When we think of the hours of labor he must have spent to give us a way of getting this electricity, we are glad that he is so honored.

We, too, can obtain electricity in a way similar to that of Volta.

Let the pupils produce some by using a lemon and strips of copper and zinc. (82, p. 124) They can easily manipulate a small homemade electromagnet. Of course, the whole class probably will not do this but several members may want to try it out and then demonstrate it.

The dry cells that you use to light your bicycle, the cell that you used in your flashlight at camp last summer, and the storage cells that make up the battery you find in your automobile have used this idea discovered by Galvani so many years ago.

A simple cell may be made. The pupils can detect the presence of the current by tasting it, or by fastening several cells together, operate an electric bell.

The chemist writes sulphuric acid $H_2 SO_4$. When the simple cell is in operation the sulphuric acid is split into two parts, H_2 and SO_4. (50, p. 31) Hydrogen bubbles move toward the copper strip and collect there. The zinc unites with the sulphur and oxygen to form zinc sulphate, a new substance. How strange it seems that this chemical action can produce electricity! Due to chemical action between the acid and the zinc "some of the molecules, atoms, and electrons are separated" and electrons are, of course, tiny bits of electricity. Millions

of electrons exchange places back and forth through the liquid." (50, p. 32) The electrons pile up on the zinc plate (or negative plate) in great numbers, but only sparsely on the copper plate (or positive plate). This continues to take place as long as the chemical action goes on. If the zinc plate is connected with the copper one by a good conductor of electricity, the electrons from the zinc plate will rush over to the copper to make a balance. (50, pp. 30 - 32). This march of electrons is what we call an electric current. The hydrogen formed by the chemical action on the copper plate insulates it and prevents the flow of current. The cell is then said to be polarized. For this reason Volta's simple cell was not successful.

Why do your dry cells deteriorate even if you do not use them? What is the white material that collects on the outside? Why can you make your cells come to life again by boring holes in the side and placing them in water?

Let the pupils take apart old dry cells to discover for themselves the construction.

The dry cell is based upon the voltaic principle. A mixture of manganese dioxide and powdered carbon (which fills the space between the carbon rod and the zinc can) in addition to the piece of porous paper which lines the container, is soaked with a solution called sal-ammoniac

or ammonium chloride. It is this that acts chemically upon the zinc. Evidence of this chemical action is detected by the white material called zinc chloride that is seen sometimes on the outside of the cell. Also, in old dry cells we find holes in the zinc can which means that the zinc has been partly consumed by the chemical action. The zinc therefore acts as a fuel. Then a large cell will naturally last longer than a small one because it contains more zinc. The carbon rod, extending through the center, takes the place of the copper plate in Volta's cell and acts as a conductor. But this cell does not polarize as easily because the manufacturers have put manganese dioxide in the mixture, the oxygen of which unites chemically with the hydrogen as it is formed to produce water. Since this action takes place slowly, this cell is suitable for intermittent use only.
(36, p. 667)

When the moisture evaporates from the cell, the sal-ammoniac can no longer act upon the zinc and therefore it becomes useless. This often happens to cells that are allowed to stand without use. The sealed top, however, prevents the evaporation from going on as rapidly.

The children are always amused to discover that a dry cell that is really dry is no good.
When a cell will not work any longer it can be revived (provided that the zinc has not been consumed) by boring

holes in the can and placing it in water because this supplies the necessary moisture. What a convenient cell it is! All the contents are neatly held and sealed in the zinc can with no danger of any liquid spilling.

Opportunity might be given for students who wish to do so to make cells of their own with sal-ammoniac, and the carbon rod they removed from the old dry cell. (52, p. 50)

The pupils may discover also how they can fasten several cells together to form a battery and thus manipulate electric toys that they have at home. As a result they may find out the difference between parallel and series connections, the value of each, and the necessity of always having a complete electric circuit. Also they have possibly, in trimming their Christmas trees, found that if the lights went out that they had to try all of the bulbs to discover which one was breaking the circuit. They will, therefore, be interested to learn that lights may be connected in series and in parallel; that our houses are wired in parallel, while the Christmas tree sets are often wired in series, and that when one bulb burns out, the circuit is broken.

Why does your father need to pay so much attention to the storage battery in his automobile? Why does he need to test it about every two weeks? Perhaps you have wondered, too, where the electricity comes from that charges the automobile battery. Your father does not need to remove it and charge it himself.

The pupils will be curious to know why a storage battery needs to be charged but a dry cell does not; also how a battery tester tests a battery. Rules for the care of a storage battery can be drawn up. Some schools use a kind of storage battery for the fire alarm system. A group of students may be interested to visit the janitor to investigate these batteries.

Are the storage batteries we saw in the power house and in our school building just like the ones we have been

talking about and how are they kept charged?

The pupils will be amazed to know that huge storage batteries as tall as men, and weighing several tons, are often used in direct current substations to supply "continuous service in case of accidents . . . Some cells contain as many as 137 lead plates and 180 gallons of sulphuric acid." (50, pp. 131 - 133) A single large storage battery often consists of 150 big cells, all connected and would fill a room 50 feet wide and 100 feet long.

What forms are taken by electricity?

What is the most common form?

How do we look for it?

How can we detect it?

But electricity shows up in unexpected ways. A girl scuffed her feet across a heavy rug as she walked over to the table to smell a bouquet of carnations. As her nose came in contact with the flowers, a blue spark appeared and she felt a sharp prickly sensation on the end of her nose, which made her jump. You, too, have had similar experiences. Why do you see sparks when you stroke a cat's back when in a dark room? When you comb your hair on a cold winter morning, why does it stand out from your head? Not only have you all had such experiences but you have observed the man placing gold letters on store windows. A rub or two of the brush on his hair makes it easy for him to pick up the flimsy gold leaf. Or you have noticed that after writing on a piece of paper it sticks to the desk and that papers coming from a printing press often stick together or even sometimes fly apart. Of course, these

phenomena may be noticed only on cold dry days. (51, pp. 160 and 161) Many industries spend much time and thought in planning for correct atmospheric conditions so that static electricity will not cause sheets of paper to fly apart, thus slowing up production and increasing cost. Especially is this true in printing.

These and many other instances will arouse a curiosity which may lead the children to investigate the cause of these mysterious occurrences.

Rub a hard rubber fountain pen on your coat sleeve and hold the pen over small bits of paper on your desk; then hold the paper against the wall. Can you explain the action? Rub a balloon, stretched on a string across the room, with fur. Touch the balloon with your fingers. What sensation do you get? Listen! Do you hear the crackling? If the room were darkened, you could actually see the sparks. Such discharges as these, but on a larger scale, you will see in the sky this summer, following a stretch of very warm weather.

Someone may wish to find out what the people who lived years ago thought of these phenomena. What the Greeks knew about static electricity and what Benjamin Franklin's contributions and experiences will be stimulating. He will be interested, when investigating the former, to find out how the word electricity originated.

An experiment with balloons, or with pieces of cork which are suspended by silk thread (50, pp. 2 - 4) in which several are charged alike and brought together will increase the curiosity of the pupils. They will wonder why these charged objects behave so peculiarly.

Electricity may be present in everything - in our clothes, in our hair, in our desks, and even in our shoes. (50, pp. 2 - 4) We do not notice it unless there is more or less than usual; it is like air in this respect, for unless there is too much air in our automobile tires or not enough we do not notice it. All bodies contain two kinds of electricity, positive and negative, but only the negative electricity or electrons in the body can move.

When we comb our hair vigorously on a cold winter morning or scuff our feet on a rug, we rub off some of the tiny electrons, transferring them to other substances so that one substance has a greater number than usual and another substance fewer than usual. It is then we notice electricity, for when two bodies with differing numbers of electrons are brought near each other, the electrons in the substance which has the greater number try to move to the one with the fewer to make a balance. This causes attraction and a spark results if the difference between the charges is great enough. Substances which have the same charge will have no attraction for each other and in fact will repel one another. Such discharges as result from unlike charges coming together or near each other we see during a thunder storm.

Each child may be given a pith ball and a piece of sealing wax. By rubbing the sealing wax on his coat sleeve and then holding it over the pith ball, he will see that the ball jumps up and down between the sealing wax

and the desk. Children are always very much interested in this peculiar behavior which illustrates well the transference of electrons.

And so when clouds become charged with electricity, one positive and one negative, a transference of electrons takes place, causing a flash, the intensity of which depends upon the distance between the clouds and the amount of the charge. Sometimes an object on the earth and a cloud are attracted and a discharge takes place between them. It is said that it requires a charge of a thousand volts for lightning to jump one fifth of an inch through the air. (52, p. 100) Can you imagine the enormous number of volts represented by lightning when the distance between clouds or between a cloud and the earth may be a mile or more? (15, p. 151) Lightning flashes as long as two miles have actually been observed. (52, p. 100)

Doubtless some children in the class are victims of hay fever. If so, they will be eager to know some of the late developments for their benefit. Not only do we have demonstrations of the attraction between clouds and charged pens and pieces of paper but man has utilized this same principle of attraction between oppositely charged bodies in the recent device for cleaning air electrically. Hay fever victims who have used the cleaner state that relief comes to them within fifteen minutes after they have been in a room where the air has been cleaned in this way. (71, p. 94) Pupils will probably wish to look into this for themselves.

Is there need of fearing electricity in its most common form?

What precautions should we take?

Why do houses in the country have lightning rods while you seldom see them on buildings in large cities? Why are tall buildings and people in open fields struck more often than low buildings and people in the woods? The Connecticut Yankee in Mark Twain's story used the lightning rod for a different purpose. The Connecticut Yankee was able to destroy Merlin's Tower by magic, as far as the natives were concerned, but all because he understood how the lightning rod worked. How cleverly he made use of the common thunder storm!

The lightning rod really serves as a conductor of electricity. Lightning rods that are used in houses in the country are made of metal and carry the electricity away through the ground, thus preventing the lightning from striking the building. In large cities the steel sky-scraper and electric wires serve this purpose. (85, p. 36)

Although lightning is such a tremendous force, we do not need to fear it if we observe a few simple rules.

The National Fire Protection Association suggests helpful and practical rules for personal conduct during thunder storms which some pupil will be eager to present to the class. (56, p. 6) The following are those suggested:

"(a) Do not go out of doors or remain out during thunder storms unless it is necessary. Stay inside of a building where it is dry, preferably away from fireplaces, stoves and other metal objects.

(b) If there is any choice of shelter choose in the following order:

(1) Large metal or metal frame buildings.

(2) Dwellings or other buildings which are protected against lightning.

(3) Large unprotected buildings.

(4) Small unprotected buildings.

(c) If remaining out of doors is unavoidable, keep away from:

(1) Small sheds and shelters if in an exposed location.

(2) Isolated trees.

(3) Wire fences.

(4) Hilltops and wide open spaces.

(d) Seek shelter in a cave, a depression in the ground, a deep valley or canyon, the foot of a steep or overhanging cliff, dense woods or a grove of trees." (56, p. 6)

We need to keep in mind that hills and high objects are more likely to be struck than hollows because they are nearer cloud masses. (15, p. 151) A person in an open field is the highest point and is therefore more likely to be struck.

What is thunder and why does not the thunder always follow the lightning flash immediately? Did you realize that after you have seen the lightning, the danger is over for that particular flash, for the thunder is merely the result of the rapid contraction of the air?

The rules or laws of insurance companies concerning lightning rods may be investigated. That a reduction of 5 percent[1] is made by some insurance companies for buildings classed as dwellings that are provided with lightning rods is a fact that the pupils will be glad to know.

1 This figure is quoted from the New England Insurance Exchange in Boston.

Only three persons in every million of our population were struck down annually by lightning in the last ten years. Outdoor rural workers are in much greater danger than city dwellers, so certain agricultural states have a higher lightning mortality. (73, p. 155)

"The number of fatalities from lightning is shown by Census Reports to be about 500 per year for the entire United States. . . . The lightning hazard is greatest among persons whose occupations keep them outdoors, a conclusion which is supported by the general run of reports of such casualties.

"The number of fatalities from lightning is insignificant in comparison with the number from all other accidental causes, which approximates 100,000 annually. ... Within buildings of considerable size, and dwelling houses of modern construction, cases of injury from lightning are relatively rare. They are more frequent within small unprotected buildings of the older type. Isolated school houses and churches where numbers may congregate during thunder storms present a considerable lightning hazard if unprotected." (56, p. 6)

Yes, lightning is the same kind of mighty force that we control by pushing the button on the wall. This is the only kind of electricity man knew up to about a hundred years ago. Now he produces electricity and commands it to serve him, but as yet he has found no way of controlling it in its natural form. Thunder storms come and go but the tremendous force cannot be used.

We have seen the huge generators that man has used to produce this force on the earth and have found that this magic genie serves us well in giving us comforts undreamed of by our ancestors. But can we think of these comforts without thinking of one whose untiring efforts gave us

a better way of dispelling the darkness in our homes when the shadows of night creep down upon us? Who was he?

To know the man, the "wizard of Menlo Park," who has made possible many of our modern conveniences will be of vital interest to most of the pupils. An appreciation of the endless efforts, persistence, patience, and courage of a great scientist can be developed. Since it is possible to visit the very place where Edison lived and labored, the whole story of his work can be made to seem very real to the pupils. They may even plan an imaginary trip to Menlo Park, New Jersey.

And now we may say of electricity,

"For ages this giant roamed about, destructive and unrestrained, keeping people in constant fear and superstition. But there were among men a few dauntless pioneers, Franklins and Edisons, who trailed the genie to his very lair. They matched quickness with persistence, and brute strength with ingenuity, until finally they captured the mighty giant, disciplined him, and trained him for useful and obedient service to mankind." (50, p. ix)

The purpose of this unit is to develop an appreciation of the wonders underlying our commonplace environment and the power man has gained in controlling for his benefit such mighty forces as electricity. In trying to fulfill the aim stated above, an attempt has been made to develop certain correct attitudes, appreciations, interests, and desires. Some of these are correct attitudes toward thunder storms, freedom from fears and superstitions, respect for the expert, appreciation of the care that must be taken in handling large currents in order to secure safety, appreciation of the work of the scientist and his method of attacking problems, and interest in things electrical with a possible desire to further study.

Films:[1]

General Electric Company:

"Edison - The Benefactor" (43, p. 304)

Eastman Classroom Films:

1. "Chemical Effects of Electricity"

2. "Water Power"

Supplementary Reading List:[1]

1. Bragg, W. L. - Electricity. New York: Macmillan Company, 1936.
   (Chaps. I, II and IV, pp. 1-182)

2. Clarke, C. R. and Small, S. A. - The Boy's Book of Physics. New York: E. P. Dutton Company, Inc., 1922.
   (Chap. XIII, pp. 221-246
   Chap. XV, pp. 267-275)

3. Lunt, J. R. - Everyday Electricity. New York: Macmillan Company, 1927.
   (Chaps. III - XIII, pp. 20-160
   Chaps. XV - XVIII, pp. 181-239)

4. Meister, M. - Magnetism and Electricity. New York: Charles Scribner's Sons, 1929.
   (Chaps. IV - IX, pp. 43-105
   Chaps. XII and XIII, pp. 131-152)

5. Morgan, A. P. - A First Electrical Book for Boys. New York: Charles Scribner's Sons, 1935.
   (Chap. I, pp. 1-23
   Chap. II, pp. 39-51
   Chap. VI, pp. 87-110
   Chaps. X - XVI, pp. 126-205)

1 This list is merely suggestive of enriching material available. It is not intended to be complete.

6. Morgan, A. P. - The Boy Electrician. Boston: Lothrop, Lee, and Shepard Company, 1929.
(Chaps. II - VIII, pp. 16-140
Chaps. XII and XIII, pp. 194-236
Chaps. XVIII - XXI, pp. 317-400)

7. Parker, B. M. - The Book of Electricity. Boston: Houghton Mifflin Company, 1928.
(Chaps. I - VII, pp. 1-87
Chaps. XIX - XXI, pp. 138-168
Chaps. XXIII - XXVI, pp. 183-215)

8. Simonds, W. A. - A Boy with Edison. New York: Doubleday. Doran and Company, Inc., 1931.

UNIT IV. Our World of Sound.

As I sat listening to the concert presented by the members of our band and orchestra last night, I could not help thinking of the many kinds of instruments man has invented. If a curtain could have been parted to make it possible for us to compare the instruments of men many years ago, what would we have seen? Listen!

Have an old tom tom at hand and produce a few sounds on it.

How did the Indians produce their music? Have any instruments been invented since our grandmothers' day? How many kinds of instruments were there in the orchestra last night? How did each of the players produce the sound on his instrument?

The children may want to investigate some of these questions.

Yes, what an array of instruments there are - violins, 'cellos, trumpets, trombones, flutes, clarinets, brass horns, drums, and cymbals, and I have heard of bassoons, bass viols, and many others.

Let the pupils imagine that each is a member of the orchestra. Each plays a particular instrument. Give opportunity for each to make his choice. Those who actually play instruments might be allowed to make first choice. Try to have as many represented as possible. Of course, they will want to know the general construction. Time may be given for that purpose. Diagrams can be drawn and a visit to the music instructor made to allow them to look at instruments and also to find out how the sounds are produced by the ones they chose.

What causes sound?

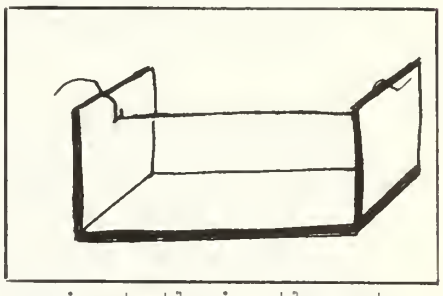
How is the sound produced in stringed instruments? in wind instruments?

"It is a mistake to think of music as a luxury to be enjoyed only when all other wants of man are satisfied. Music may be called the universal language of man. It is almost as important a form of expression as the spoken language, and can be traced back to the earliest days of civilization of even the most savage tribes. The way in which music is produced is as simple as it is wonderful. Whether it be a violin, a piano, an organ, a phonograph, or the human voice, music is simply a form of sound." (65, p. 128)

The sounds made by different instruments are not alike. We are glad that they are not because they make possible more pleasing effects when played together. Musical instruments make pleasant sounds that we like to hear, but all sounds are not pleasant. Slam a book on the table, crumple a piece of paper, and slam a door. Listen! What did you hear? Perhaps the clicking of the clock at minute intervals, an automobile horn, someone talking in the next room, but these are not all pleasant sounds.

Why does the drawing of the bow across the strings of your violin, the slamming of a door, or the crumpling of paper produce sounds? Let us watch a few things.

A group of things that can be used to produce sound could be used here. Use small wooden stands across which may be stretched a piece of wire or catgut. These can be made in the manual training department at little cost. Have them pluck the string and watch it carefully. Give them each a tuning fork. Ask them to strike it and hold it against a piece of paper. (65, p. 129) Ask them to hold their fingers against their throat as they repeat a word or statement in unison. Demonstrate a few other instances. A large vibrating bell can be placed against some pith balls or a vibrating tuning fork can be placed in water. (90, p. 96) Finally, a picture of these vibrations can be made. (7, p. 428)



If we try each time we hear a sound, whether it be the sound from a musical instrument or from some other source, to determine its cause, we shall find that something is vibrating.

Ask children who actually own instruments to bring them to class. Have them produce sounds on them and have the class watch.

In stringed instruments such as the 'cello, violin, mandolin, ukelele, and harp the sound is produced by causing the strings to vibrate. This is accomplished by either drawing the bow across them, as in the violin and 'cello, by plucking the strings with a pick or the fingers, as in the harp and banjo; or by thrumming, as in the mandolin or ukelele. The columns of air in wind instruments are set in motion by the vibrating of the lips. In some cases, as in the saxophone, a reed is made to vibrate first.

How can musical instruments produce notes of different pitch?

How can we produce high and low notes with our voices?

Why do some people have higher pitched voices than others?

Such questions as the following can be brought to the attention of the pupils. Why is your horn (trombone) larger than the cornet? Why do some of the students in this room have lower voices than others? What happens when a person has laryngitis? The children will also want to know how the violin player can make sounds low or high (pitch) when he has only four strings to work with and how the trumpet player, who has only three keys (valves), can do likewise. A sonometer may be used here and the demonstration suggested on page 65 of "Problems in General Science" by Hunter and Whitman done. For the

illustration of how the pitch of wind instruments is controlled, see part "B" of demonstration 8 on page 96 in "Our Environment - How We Use and Control It" by Wood and Carpenter.

Time can be taken here to allow each pupil a chance to discover how the person in playing the instrument he has selected is able to change the pitch of the strings or air column so that he can play a tune. This may be done by asking for a volunteer from the string group of our orchestra, one from the brass wind, one from the wood wind, and one from the percussion section. Of course in the last section it will be necessary to explain that drums are for the purpose of rhythm and cannot be tuned as other instruments, but it should be shown that the pitch can be changed to some extent.

Instruments such as the 'cello, banjo, violin, and ukelele can be made to produce a wide range of notes with but few strings by shortening the vibrating length of the string with the finger, and the instruments can be tuned by tightening or loosening the strings by means of pegs which when turned wind the strings around them. Some of the strings are of greater diameter, causing lower tone. The piano or harp are fine illustrations of the effect that length and diameter of strings can have upon pitch.

Here some of the pupils will be interested to examine the piano and make a special report to the class. Pitch in wind instruments is changed by adjusting the length of the column of air. This is done by use of the valves which when pushed either open or close tubes of various lengths. In the sliding trombone, where there are no keys, pitch is changed by moving the slide in and out. This increases or shortens the lengths of the tubes. The pipe organ is an excellent example of how the size of the

air column can affect the pitch.

We ourselves are the owners of one of the most wonderful of musical instruments.

(See Powers, Neuner, and Bruner, "Man's Control of His Environment," page 506. The rubber can be stretched or loosened to show how the pitch may be varied.)

In a small boxlike structure located at the top of the windpipe is a set of vocal cords. They are in a way like the strings of the instruments we have been examining, but of course they are made of a tough, thick material very unlike those of the violin. When we talk, we stretch the cords and force air over them. This causes them to vibrate and a sound results. When we sing, we tighten or loosen them to produce the various notes in the scale.

What is laryngitis?

This is an opportunity for a special report by some member of the class.

"Laryngitis is an acute inflammation of the mucous membrane of the larynx, sometimes extending to the submucous tissue and muscles." (37, p. 265)

Sometimes parts of the larynx become so swollen as to entirely cover the vocal cords. This prevents the vocal cords from functioning properly and we say the person loses his voice. (37, p. 265)

How can we hear the sound of a distant airplane?

Does sound travel at the same speed as light?

What is an echo?

You have listened to the music of our band and orchestra. Probably some of you sat at the back of the hall; some of you may have sat near the front. In either case you had no trouble in hearing. How did the sound reach you? How could you hear the voice of the announcer? How can you hear the sound of a distant train or airplane? Yes, indeed, our air acts as a carrier.

"Imagine if you can, what a strange world this would be if the air suddenly lost its power to transmit sound. All spoken language, all conversation, would become useless, and would have to be discontinued as a means of communication. No longer would there be any use for the telephone in its present form. The mighty thunder would no longer have terror for those caught in a storm, and the roar of the wind-lashed sea would become unknown. Music, sweet, comforting, pleasure-giving music, would be denied us, and all the world would be quiet and solemn with the awful stillness of a tomb." (65, p. 130)

Such would be the case on our moon if, indeed, anyone could live there.

You have noticed that when you stand in front of the piano and draw your bow across the violin strings, that sometimes a string in the piano seems to respond.

In connection with this, stand two mounted tuning forks of the same pitch on the table. See "First Principles of Physics" by Fuller, Brownlee, and Baker, page 309, experiment 98.

When one object is set in motion like the string of your violin, the vibration is carried by the air. If the air strikes a string in the piano that is the same thickness and length, the string in the piano will vibrate, too, and produce the same sound. This is called sympathetic vibration.

Sometimes the air will carry the vibration (caused by a great explosion) to the windows of a house and cause them to vibrate to the extent, sometimes, that the windows break.

Why do people say one can tell how near a thunder storm is by noting the time between the flash and the crash?

The pupils may have noticed that the flash of lightning is often seen some time before the crash of thunder is heard, or have noticed that the steam is seen coming from the whistle of a boat before the sound is heard.

Sound really travels much more slowly than light. In 1823 an experiment that showed how fast sound really does travel in the air was completed.

"Since light is practically instantaneous for short distances, the velocity of sound can be determined by dividing the distance between a gun and an observer by the time interval between the flash and the report.

"This was the method used in 1823 by Moll and Van Beek, two Dutch scientists. They placed a cannon on each of two hills about eleven miles apart. The two cannon were fired and the time between flash and report noted by the observers on each hill. The average of a number of observations showed that sound traveled about 1100 feet per second in air. Two cannons were used to avoid any error due to wind. Accurate determinations show that the velocity of sound in air is 1090 feet per second at 0° C." (36, p. 379)

The teacher may bring in here also the effect of varying temperature upon the velocity of sound.

Light will reach its destination much more quickly traveling at the rate of 186,000 miles in one second. (7, p. 490) It is no wonder, therefore, that we see the flash of lightning some time before the crash is heard if

the storm is some distance away from us; but, of course, if the storm is really upon us, we must expect that the lightning and thunder will come together.

Most of the pupils will certainly be acquainted with the fact that when two stones are clapped together under water, the sound is much louder than if they were clapped together in the air.

Although we depend upon air to carry our voices, the beautiful music of an orchestra, or the sound of an approaching automobile, it is not the best conductor of sound. "The speed of sound in water is about 4.5 times the speed in air." (7, p. 430) A means of "communication between lightships and vessels nearing land and between vessels approaching each other, particularly in a dense fog" (36, p. 380) has been established because of the greater ability of water to carry sound. "Part of the vessel acts as a sounding board, and the signals are sent or received by delicate apparatus. This means for detecting sound waves passing through water gives a means for the accurate location of vessels." (36, p. 380)

We are told that some solids can act as even better conductors.

The teacher may perform at this time the demonstration suggested on page 134 in "Water, Air, and Sound" by Reh, to show the differences in substances to conduct sound.

The speed of sound through steel is 15 times as great as in air.

In the Indian stories that we have read, we have noted that those aborigines often detected distant sounds by placing their ears against the ground. The earth acted as an excellent conductor. People who find it necessary to walk along railroad tracks can detect the approach of an oncoming train by holding their ears against the track because the steel will carry to them the sound of an approaching train easily and quickly.

At this point, to show that substances that carry sound really carry vibrations and that they must therefore vibrate themselves, would increase an understanding of conductors.

We enjoyed the music of our orchestra last night because, as you said, you could hear plainly even although you sat at the back of the hall and you had no difficulty in hearing the announcer. But we shall have to thank the one who planned our hall for the excellent acoustic properties. Although air can carry the sound to us, unless care is taken, the walls of the hall can act as a mirror does to light and reflect or turn the sound back. We call these reflections echoes if the object is some distance away.

"At Echo Lake in Colorado, a hello is returned so promptly and clearly that a person may enjoy talking to himself." (89, p. 22)

"Unless successive sounds are 1/10 of a second apart, the ear cannot distinguish them as separate sounds. During this tenth of a second, sound travels 110 feet so a wall must be 55 feet away to give a distinct echo. In an ordinary room the nearness of the walls enables the

sound reflection or echo to return to the ear in time to prolong the original sound.

"In an auditorium, the reflected sound waves may return at such intervals as to overlap the words of the speaker to the confusion of the listeners." (36, p. 384)

The children will undoubtedly enjoy finding out what the ancients thought of the echo.

Sometimes sound waves can combine to produce no sound.

This might be investigated by some of the students.

The man who planned and built our auditorium had to take into consideration all of the above. Some builders so construct walls and ceilings that the sound waves will travel in parallel lines and return to the source. They construct walls and ceilings that cause conflicting sound waves of dead or non-reflecting materials. Sometimes huge reflectors are placed behind the speaker, for sound waves can be reflected and concentrated.

"The Shell. located on Swift Bridge in Chicago during the Century of Progress,was used to reflect the sound of the Chicago Symphony Orchestra to the sudience across the water in the open air auditorium." (89, p. 23)

"Careful experiments by Sabine at Harvard University a few years ago showed that a room must have a reverberation of almost exactly one second to be good for orchestral music. He also showed, not only how to correct excessive reverberation by putting felt on the walls or ceiling, but by using sound absorbing furniture, hangings, statuary, or plants, but also how to design new auditoriums so that they shall have just the right reverberation, by choosing proper materials for the walls and ceilings. He even made acoustically good stone churches possible by finding a special kind of artificial stone or tile that absorbs many times as much sound as ordinary stone." (7, p. 442)

You have all experienced that your voices often echo in an empty room but do not in the same room when it is filled with furniture and the rugs and draperies are in place. Soft materials such as cloth, soft rubber, and the like absorb the sound waves.

Certainly some of the students have noticed that often thunder rolls and will be much interested to know that the sound is reflected between the clouds and the earth.

We have talked about the instruments in the band and orchestra and how they produced the beautiful music. We have found how the sound reached us but have you ever stopped to think of a far more wonderful instrument than any we have mentioned - the one instrument that made the enjoyment of that concert possible? What is it?

What is sound? Would Niagara Falls still continue to roar if there were no living things on the earth? Probably you have never thought of this before, but there are really two things that are called sound - "the vibrations and the sensations they produce when they strike against the ear drum of our ear." (7, p. 431) When we hear a sound, a sensation is registered in our brain. Our ears serve as a passage for the necessary vibration.

How does our ear carry vibrations?

How can we hear the different notes of the scale?

Why do older people often become deaf?

When one goes up a mountain, what causes the peculiar sensation in one's ears? Why will swallowing often relieve it?

These and other questions will bring to the attention of the children the wonder of the delicate instrument that opens our minds to the things that are going on around us.

When the strings of the violin in the orchestra were vibrating, the air was set vibrating and the vibrating air came in contact with a membrane in our ear. This membrane is called the ear drum and is situated at the end of a long auditory canal. We say this canal is long and it really is when we compare it with other parts of this delicate instrument, for it is 21 to 26 mm. (44, p. 376) in length, whereas the eardrum is 0.1 mm. in thickness. The fleshy part of the ear is full of many folds and helps to direct the sound waves into the auditory canal. It helps "to some extent in intensifying the appreciation of sounds and also enabling us to determine their direction." (44, p. 376) Older people who are deaf hold their hands in the form of a cup in back of their ear in an attempt to direct and collect the sound waves. Dogs prick up their ears or make their ears more cup-shaped when they are listening. The vibration of the eardrum is passed along to the three little bones in our middle ear. The bones, called the hammer, the anvil, and the stirrup, act as a chain or bridge to carry the vibration on to the inner ear. Older people have difficulty in hearing because the bones become stiffened and cannot oscillate as freely. The stirrup transfers its vibration to an inner eardrum and

then to the fluid inside of the inner ear or cochlea as it is sometimes called. The cochlea, which looks much like a sea shell, contains one of the most delicate and wonderful mechanisms one can imagine. In this inner chamber is a structure containing about 24,000 strings varying gradually in length and resembling in general arrangement the strings of the piano. (44, p. 389) They act much as the strings in the piano act when we stand before it and draw the bow across the strings of a violin. We have seen that if we do this, corresponding strings in the piano will respond. The vibrations which enter the fluid in the cochlea affect the strings or fibers of this marvellous instrument in the same way. These tiny filaments transmit the sensation to a large auditory nerve which carries the sensation to our brains.

Each note of the scale on the piano is produced by a certain number of vibrations per second and the human ear is limited to the number of vibrations it can interpret. The following table gives the frequency for each note in one octave, according to International pitch.

Middle C - 258.6
D - 290.3
E - 325.8
F - 345.2
G - 387.5
A - 435.
B - 488.2
C - 517.3

(36, p. 419)

Each note in the next octave higher will have twice as many vibrations as the corresponding note in the octave given while each corresponding note in the octave below will have just one half as many vibrations per second. The human ear cannot detect sounds that are produced by less than 16 vibrations per second or more than 40,000. It is believed that many sounds produced by insects are not heard by us and that the ears of some wild animals are constructed so that their range of hearing is different.

The children will be fascinated here to find out whether frogs, fish, grasshoppers, and the like have ears and how they hear.

The eardrum is such a delicate membrane that any undue pressure against it might break it; so nature has provided everyone with a tube extending from the middle ear to the throat. Whenever we ascend a mountain and the air pressure gradually decreases, the pressure on the outside of the eardrum is lessened. We unconsciously swallow to let air in through our eustachian tube. This balances the air pressure on both sides and prevents the eardrum from breaking.

Because this instrument is so delicate it needs care. A story tells us that Thomas A. Edison was boxed on the ears by the train man and that he, as a result, became deaf. Why is boxing the ears harmful? What is the purpose of the wax in our ears? Should an excess be allowed to collect? How should wax be removed? Should we protect

our ears when we are doing deep diving? Is it true that nose and throat trouble can affect our hearing?

These questions should arouse an interest in the care of the ear. The teacher may handle this by having the children investigate these questions and then draw up a set of rules on the care of the ear.[1]

An excellent way to end a unit of this type will be the preparation of a program to be presented in the school assembly or to a group of parents. Selections by those in the class who actually play instruments can be used to open the program and the scientific side of sound can be presented by the members of the original orchestra formed in the class. Some of the members of the class even might have made crude instruments of some kind. A demonstration of these should certainly be included.

The aim of this unit is to develop an appreciation for the wonders underlying our commonplace environment.

1 When the children are making discoveries about the ear, a model or film should be at hand. Either one or the other is essential.

Supplementary Reading List:[1]

Abbot, C. G. - Mysterious Secrets of Science in the Home. New York: Macmillan Company, 1923.

(Chap. XIV, pp. 124-136)

Meister, M. - Living in a World of Science. Water and Air. New York: Charles Scribner's Sons, 1930.

(Chap. XIII, pp. 182-196
Chap. XIV, pp. 197-208
Chap. XV, pp. 209-218
Chap. XVI, pp. 219-231)

1 This list is merely suggestive of enriching material. It is not intended to be complete.

5.

CHAPTER IV

Criteria for the Choosing and Development of Units and Further Suggested Units

It is evident that there are certain standards by which the selection of appreciation units in general science may be made. Perhaps first and foremost is the consideration of what materials are best suited to the development of correct attitudes, ideals, and appreciations. The units should interest the child because they are a part of his life. They should be centered about some "focal point" or "meaningful experience" and should be related to big scientific meanings that form a nucleus or core for the entire unit. H. Hultz in speaking of this fundamental thread of unity illustrates by saying that

> "children cannot work out a history of people's beliefs about the sky without realizing how scientific knowledge has replaced superstitious beliefs" and that "children who know the development of lighting will have more appreciation for the scientific method. Such concepts form the organization points throughout a science program made up of units such as those described." (45, p. 16)

In developing such units it is essential first to secure an atmosphere of interest. Pieper says that it is "necessary that the pupil be stimulated and oriented with respect to the new unit . . ." (81, p. 214) This orientation should give a general view of the new unit in terms of the child's present experiences and its significance to his own life and the life of the community. Downing says,

in speaking of all types of units, including appreciation, that "the unit may begin with a challenging introduction." (25, p. 102)

Once stimulated, the pupils should be given an opportunity to come into contact naturally with the material from which the teacher wishes to develop correct attitudes, ideals, and appreciations. In science this may be a visit to an industrial plant, the examination of an electric motor and visit to a scrap iron yard, or an activity chosen by the pupil. This will serve further to develop interest. Throughout the entire unit experiences that lie closest to the lives of the students and that are of present interest to him should be used as starting points. In the preceding units experiences such as these are employed but it must be borne in mind that they may vary with the time of year, with the type of children, or with the community. Thus the teacher must use those suitable to the existing circumstances. As the unit proceeds, such subject matter as may aid in appreciation should be used but at no time overemphasized. Such activities as creating, attempting to execute, or working in clubs provide for expression and growth and are essential to the desired outcomes of an appreciation unit. It is important that through the various activities individual differences be provided for.

Wilson in the Third Report of the Committee on the Evaluation of Instruction summarizes the development

described in the preceding paragraphs in four main steps, namely, "(1) creating an atmosphere of interest," "(2) providing proper exposure to appreciation material," "(3) giving appropriate fundamental knowledge," and "(4) providing for expression and growth." (88, p. 49)

The units included in this thesis do not constitute all of the appreciation opportunities in the ninth grade course. It is suggested that further units, such as "The Material Things in Our Environment" and "How We Communicate With Our Neighbors," might be included.

CHAPTER V

Summary and Conclusion

Science education in this country has travelled an up and down hill course. Benjamin Franklin, about the middle of the eighteenth century, really laid the foundation for our present general science courses, for at that time he established the academy in an attempt to provide a more practical type of education than had existed. Science among other practical subjects was introduced to help realize this need. However, after the colleges accepted science for college entrance the practical viewpoint was lost and attention upon subject matter was demanded of the high schools in order to satisfy the college entrance requirements. It was not until the increased prosperity of our country, about the years 1890 and 1900, made it possible for more pupils to attend our public high schools that a more practical type of education was again demanded.

General science made a beginning about ten years later in an effort to provide a unified science course that would be based on the interests of the child. "General biology and general science were developed with the idea of bringing together those elements which are needed to develop a concept, whether or not these elements are drawn from one field of science. They are integrated sciences." (12, p. 495) "The movement for general science is first

of all a protest against the present régime of unorganized subject matter." (91, p. 203) It "is, in the second place, an attempt, for purposes of instruction, to introduce a 'psychological organization,' as Dr. Dewey puts it; or a 'genetic organization,' as President Hall states the case. . . ." (91, p. 203) The sciences of the senior high school had failed to accomplish either of the above purposes and consequently a host of children lacked interest in their school work and left school in the first and second years of the high school course. They, therefore, had little chance to be introduced to the elements of the subject.

The rise of the junior high school stimulated the growth of general science and thus about 1920 it became firmly established as a high school course. It is now an important part of the junior high school curriculum.

The purpose of the present general science course, which is in accord with present educational objectives, is not the acquisition of factual information but an integrated course that will interpret the child's environment so that he may live intelligently and happily. McCalmont says,

> "According to the modern concept, the outcome of science education is a desired alteration in the life of the pupil. . . . In order that the course in general science may be purposeful for the pupils, it must help them to adjust themselves satisfactorily to their environment and enable them to live a richer life." (55, p. 291)

It is not necessary that we attempt to train children in the junior high school to be experts in the various fields

of science. They need rather to be able to appreciate the work of the expert and to know how to select wisely the services of such. Ample time will be available when the pupil reaches college for him to train definitely for a profession if he should so desire. It must, therefore, follow that the building up of appreciations, attitudes, and ideals is an important outcome of science teaching. Pieper remarks that "the emphasis on the more easily measured objectives has undoubtedly led to the unverified assumption that to know implies to do and to be," (81, p. 202) and in speaking of the lack of available objective evidence of the nature of the contributions of work in building appreciations, ideals, and attitudes, says,

> "Until such objective data are available, the teacher of science should certainly proceed upon the assumption that the science lesson for the day is filled with possibilities and opportunities for developing attitudes toward, interests in, and appreciations of, the relation of man to the materials and forces of his surroundings." (81, p. 202)

The appreciation technique of teaching seems to be in harmony with the present aims of the general science course, and, therefore, should be employed to a great extent in the teaching of this subject.

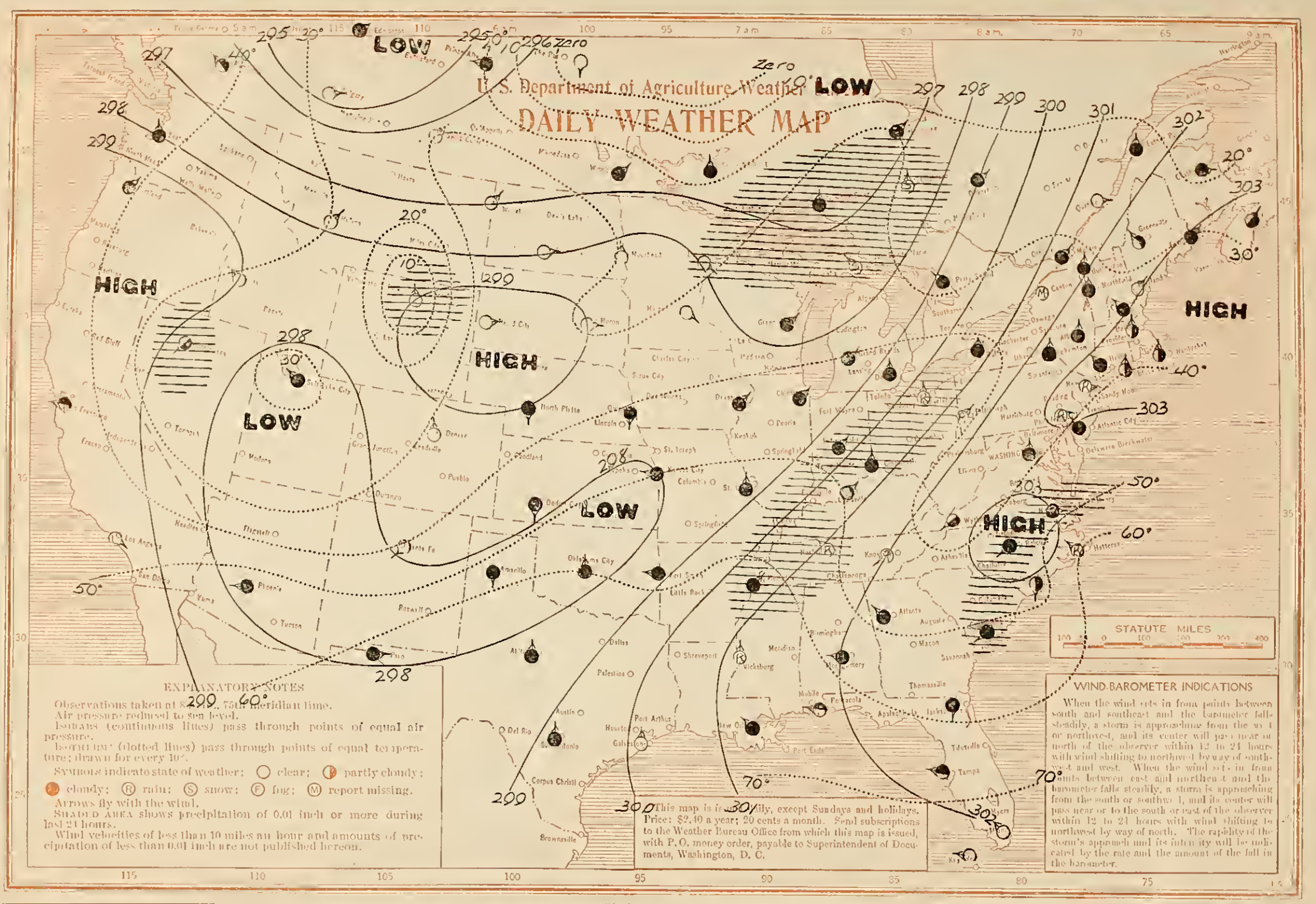
It is not unusual, however, to find teachers of science in our junior high schools upholding the view that the chief aim of general science is to learn the facts of science. Teachers of science today need to learn that general science is not a tool-drill subject, but an

opportunity for the development of general understandings and fields of interest. Appropriate fundamental knowledge, it should be understood, will aid in building such centers of interests and understandings.

Science is particularly concerned with human values. There can be no other purpose of science for the non-specialist. It is human interests only that count. In other words, the chief purpose of general science at the ninth grade level is in keeping with the general aims of the appreciation technique.

The appreciation units included in this thesis, it is hoped, may be found useful in helping to present the subject of general science in such a way as to reach the goal toward which modern education is striving.

APPENDIX



BOSTON, MASSACHUSETTS, TUESDAY, MARCH 19, 1935.

U. S. Post Office & Courthouse Building — Telephones { LIBerty, 5600, Extension, 389 to 391. (For aviation only) East Boston, 1808.

FORECAST TILL 8 P. M. WEDNESDAY

For Boston and Vicinity: Occasional rain and increasing temperature to-night and early Wednesday, followed by clearing and colder by Wednesday night; moderate to fresh southwesterly winds shifting to northwest by Wednesday night.

MASSACHUSETTS: Occasional light rain to-night and Wednesday; warmer to-night and in east portion Wednesday; somewhat colder Wednesday night.

MAINE AND NEW HAMPSHIRE: Occasional light rain to-night and Wednesday; warmer to-night and on the coast Wednesday; slightly colder in north portion Wednesday.

VERMONT: Occasional light rain to-night and probably Wednesday morning; warmer to-night; somewhat colder Wednesday.

RHODE ISLAND AND CONNECTICUT: Occasional light rain and warmer to-night and Wednesday; somewhat colder Wednesday night.

EASTERN NEW YORK: Occasional light rain to-night and Wednesday; warmer except in extreme northwest portion to-night; warmer on the coast and somewhat colder in north and central portions Wednesday.

ATLANTIC COAST, EASTPORT TO SANDY HOOK: Fresh, south and southwest winds, possibly strong at times over north portion, and overcast weather with occasional light rain to-night and Wednesday.

For SHIPPERS: Warmer to-night; protect perishable shipments moving into northern portions of New England and New York Wednesday night from temperatures in the upper 20's.

Weather Conditions

The barometric pressure continues high, but falling along the Atlantic Slope. A trough of pressure slightly below normal extends from the Mexican boundary northeastward over the Central Valleys, the Lake region, and into central and western Canada. Little precipitation has occurred except scattered light rains from the Mississippi Valley to the Middle Atlantic coast, and a few snow flurries in north-central regions. There is much cloudiness, however, in eastern and southern parts of the country. The temperature has risen generally east of Minnesota and throughout the South. Freezing weather prevails this morning in northern boundary States and Canada, and sub-zero temperatures in central Manitoba.

G. H. NOYES

Current Data

BOSTON, MASS	To-day 8 a.m.	Yesterday noon	Yesterday 8 p.m.
Barometer	30.33	.....	30.60
Temperature	34	34	38
Wind direction	s.	w.	w.
Wind velocity	14	12	8
Relative humidity	71	22	22
Precipitation in past 12 hours	0	....	0

Special Reports

Stations	Pressure	Temp.	Wind dir.	Wind vel.	Weather
Boston Airport	30.31	36	s.	12	cloudy.
St. Georges, Ber'oda	30.28	68	ne.	22	cloudy
Deer Island Light	.....	34	s.	6	p. cloudy.
* Mt. Wash. Sommit	23.72	16	sw.	45	cloudy.
North Truro	.....	38	sw.	28	clear.
Naotucket Shoals (Light Vessel)	30.40	42	s.	12	clear.

* Elevation 6270 feet

Boston Temperature Data

Mean yesterday	30
Departure from normal	−6
Departure from normal this month to date	+62
Departure from normal since January 1st	−108

Boston Precipitation Data

Total this month to date	0.62
Departure from normal	−1.58
Total since January 1st to date	10.67
Departure from normal	+0.88

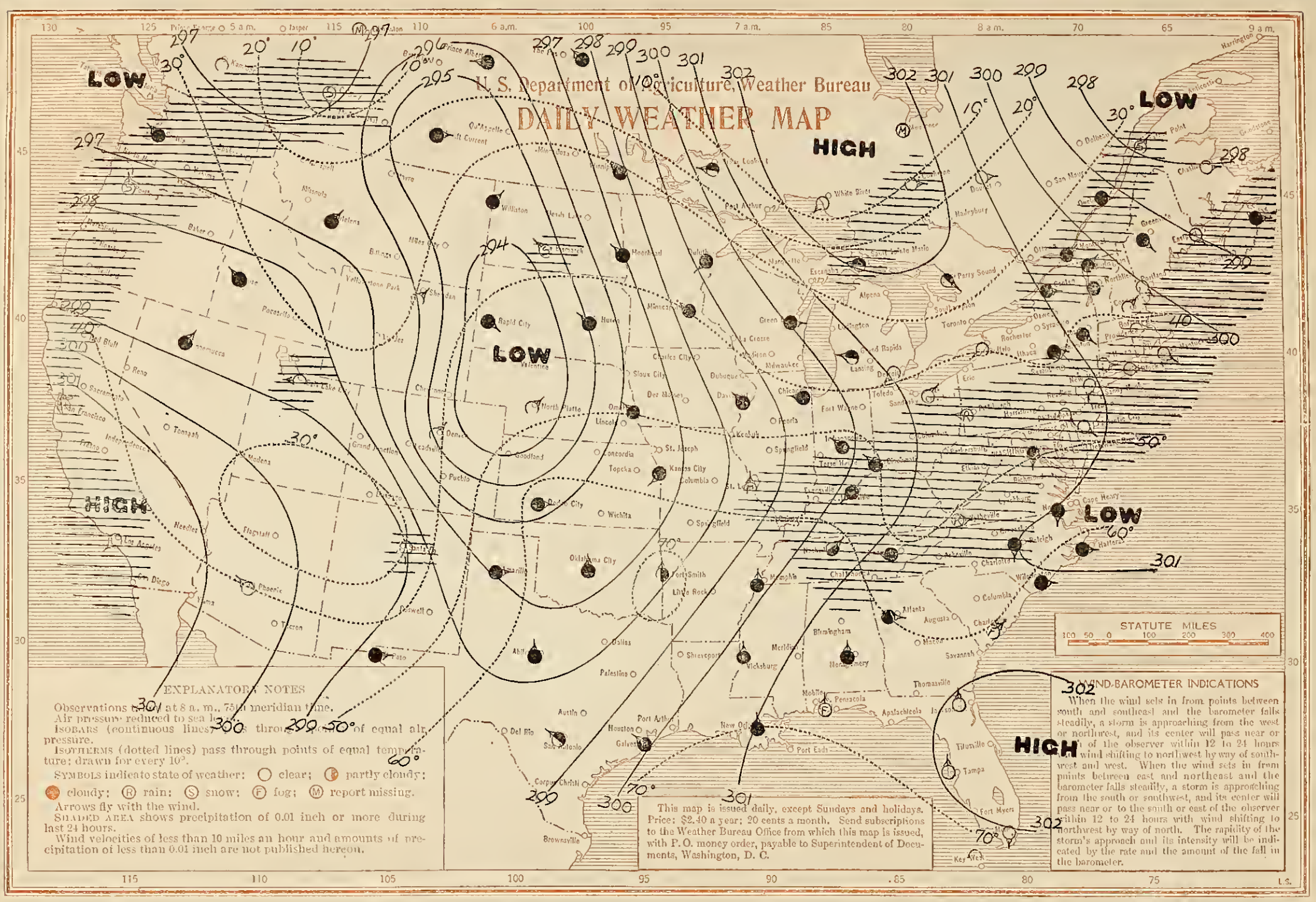
MAP DD

STATIONS.	Temperature. At 8 a.m.	Highest last 24 hours.	Lowest last night.	Wind velocity 8 a.m. to-day.	Precipitation in last 24 hours.
Abilene, Tex.	64	80	64	10	0
Albany, N. Y.	36	38	32	16	0
Amarillo, Tex.	58	72	52	10	0
Atlanta, Ga.	48	60	46	10	0
Atlantic City, N. J.	42	42	36	24	0
Binghamton, N. Y.	36	44	34	.....	0
Bismarck, N. D.	32	42	28	.....	0
Block Island, R. I.	40	40	32	22	0
Boise, Idaho	30	46	28	.....	0
BOSTON, MASS.	34	41	30	14	0
Buffalo, N. Y.	42	42	34	24	0
Burlington, Vt.	34	34	28	24	0
Calgary, Alberta	26	46	26	.....	0
Canton, N. Y.	38	38	26	14	0
Charleston, S. C.	64	66	62	.....	.02
Chatham, N. B.	16	24	6	.....	0
Chicago, Ill.	42	44	40	.....	0
Cincinnati, Ohio	48	60	48	.....	.02
Cleveland, Ohio	46	48	40	14	.06
Cochrane, Ont.	28	34	26	10	.04
Concord, N. H.	32	36	24	.....	0
Davenport, Iowa	44	48	42	.....	0
Denver, Colo	34	64	34	.....	0
Detroit, Mich.	40	40	32	10	0
Dodge City, Kans.	48	70	48	24	0
Doucet, Que.	22	28	20	.....	0
Duluth, Minn.	26	40	26	12	.02
Eastport, Me.	32	32	22	.....	0
Edmonton, Alberta	26	42	22	.....	0
El Paso, Tex.	60	80	50	.....	0
Father Point, Que.	22	40	10	16	0
Fort Churchill, Manit.	−4	.....	−8	20	0
Fort Smith, Ark.	58	50	66	.....	0
Galveston, Tex.	66	66	66	12	0
Grand Rapids, Mich.	42	42	38	12	0
Green Bay, Wis.	36	38	34	.....	0
Greenville, Me.	20	26	12	.....	0
Halifax, N. S.	24	28	22	12	0
Hatteras, N. C.	60	50	48	10	0
Helena, Mont.	30	40	30	.....	0
Huron, S. Dak.	28	60	28	.....	0
Indianapolis, Ind.	46	48	42	14	.10
Jacksonville, Fla.	58	68	58	.....	0
Kamloops, B. C.	42	56	38	.....	0
Kansas City, Mo.	50	60	50	.....	0
Key West, Fla.	74	62	70	.....	0
Knoxville, Tenn.	42	62	42	.....	0
Louisville, Ky.	54	56	54	.....	0
Los Angeles, Calif.	46	50	48	.....	0

STATIONS.	Temperature. At 8 a.m.	Highest last 24 hours.	Lowest last night.	Wind velocity 8 a.m. to-day.	Precipitation in last 24 hours
Memphis, Tenn.	62	62	52	.....	.02
Miami, Fla	72	80	70	.....	0
Minneapolis, Minn.	32	46	32	12	0
Montgomery, Ala.	56	68	54	.....	0
Montreal, Que.	32	32	28	.....	0
Moorhead, Minn.	30	52	30	.....	0
Moosonee, Ont.	30	38	24	10	0
Nantucket, Mass.	38	38	30	20	0
Nashville, Tenn.	50	50	50	.....	.10
New Haven, Conn.	36	42	34	.....	0
New Orleans, La.	68	74	66	.....	0
New York, N. Y.	38	44	32	.....	0
Norfolk, Va.	48	48	40	.....	.01
Northfield, Vt.	32	34	22	14	0
North Platte, Nebr.	32	66	32	.....	0
Oklahoma City, Okla.	60	62	58	14	0
Omaha, Nebr.	44	62	44	20	0
Parry Sound, Ont.	28	32	24	.....	0
Pensacola, Fla.	62	68	62	.....	0
Philadelphia, Pa.	38	46	32	.....	0
Phoenix, Ariz.	58	72	66	.....	0
Pittsburgh, Pa.	46	52	44	12	0
Portland, Me.	32	38	28	12	0
Portland, Ore.	40	48	40	10	0
Prince Albert, Sask.	20	34	18	...	0
Quebec, Que.	22	24	16	.....	0
Raleigh, N. C.	42	52	40	.....	.02
Rapid City, S. Dak.	32	52	26	.....	0
Sable Island, N. S.	28	38	24	28	0
St. Louis, Mo.	52	54	48	12	0
Salt Lake City, Utah	34	46	34	.....	0
San Antonio, Tex.	66	74	66	10	0
San Francisco, Calif.	44	54	44	.....	0
Santa Fe, N. Mex.	38	54	36	.....	0
Sault Ste. Marie, Mich	32	34	30	.....	.01
Seattle, Wash.	42	60	40	24	0
Sheridan, Wyo.	6	40	6	.....	.20
Sioux Lookout, Ont.	14	38	8	.....	0
Swift Current, Sask.	30	42	30	.....	0
Sydney, C.B.I.	22	30	14	10	0
Tampa, Fla.	64	82	62	10	0
The Pas, Manit.	−6	30	−6	.....	0
Vicksburg, Miss.	64	68	64	.....	0
Washington, D. C.	40	50	34	.....	0
White River, Ont.	30	34	28	.....	.06
Williston, N. Dak.	30	34	28	.....	0
Wilmington, N. C.	46	54	44	.....	0
Winnemucca, Nev.	22	42	22	.....	.10
Winnipeg, Manit.	28	36	16	12	0
Wytheville Va.	34	46	32	.....	0

Upper-air Observation above Boston

Elevation	Temp.	Rel. Humid.	Wind Dir.	Wind Vel.
2000 Feet	0	70	sw.	34
4000 Feet	0	50	w.	48
6000 Feet	−2	42	w	44
8000 Feet	−4	36	w.	36
10000 Feet	−8	34	.....	.....
14000 Feet	−16	34	.....	.....



MAP DD

BOSTON, MASSACHUSETTS, WEDNESDAY, MARCH 20, 1935.

U. S. Post Office & Conrthouse Building — Telephones { LIB erty, 5800, Extension, 389 to 391. (For aviation only) East Boston, 1808.

FORECAST TILL 8 P. M. THURSDAY

For Boston and Vicinity: Fair followed by cloudy and colder, with lowest temperature near freezing to-night; Thursday probably rain, not so cold Thursday night; moderate northwesterly winds shifting to easterly.

MASSACHUSETTS, RHODE ISLAND, AND CONNECTICUT: Cloudy and somewhat colder to-night; Thursday occasional rain.

MAINE AND NEW HAMPSHIRE: Fair and colder to-night; Thursday cloudy, followed by rain or snow in afternoon.

VERMONT: Fair and colder to-night; Thursday cloudy with slowly rising temperature, followed by rain.

EASTERN NEW YORK; Cloudy to-night, followed by occasional rain beginning late to-night or Thursday; somewhat colder in extreme north and interior of east portion to-night; rising temperature Thursday.

ATLANTIC COAST, EASTPORT TO SANDY HOOK: Moderate northwest shifting to east winds, increasing Thursday; and fair weather to-night; Thursday overcast with occasional rain.

For SHIPPERS: Protect perishable shipments moving northwest, north, northeast, for temperatures of 14° to 24°; elsewhere, 24° to 32°, to-night; not so cold Thursday night.

Weather Conditions

There is some clear sky this morning in New England and the lower Lake region, but elsewhere east of the Rocky Mountains cloudy and unsettled conditions prevail. Light snow has fallen in the last 24 hours in northeastern districts, and scattered light rains from the Central Valleys to the Atlantic coast. A ridge of relatively high pressure extends from Ontario southward over the Middle Atlantic States to Florida. A trough of low pressure extends from the British Northwest southeastward into the Western Plains States, lowest reading 29.38 inches at North Platte, Nebraska. Dust storms are prevalent in Colorado and Kansas. Temperatures have risen generally east of the Rocky Mountains except in the Lake region.

G. H. NOYES

Current Data

BOSTON, MASS	To-day 8 a.m.	Yesterday noon	Yesterday 8 p.m.
Barometer	30.03	.....	29.98
Temperature	42	43	42
Wind direction	w.	sw.	sw.
Wind velocity	10	13	6
Relative humidity	77	56	88
Precipitation in past 12 hours	Trace	.....	.07

Special Reports

Stations	Pressure	Temp.	Wind dir	Wind vel.	Weather
Boston Airport	30.03	44	w.	9	cloudy.
St. Georges, Ber'uda	30.16	64	sw.	8	p. cloudy.
Deer Island Light	.....	40	nw.	6	clear.
* Mt. Wash. Summit	23 46	18	w.	76	foggy.
North Truro	.....	40	nw	10	clear.
Nantucket Shoals (Light Vessel)	29.96	42	nw.	6	clear.

* Elevation 6270 feet

Boston Temperature Data

Mean yesterday	36
Departure from normal	0
Departure from normal this month to date	+62
Departure from normal since January 1st	−108

Boston Precipitation Data

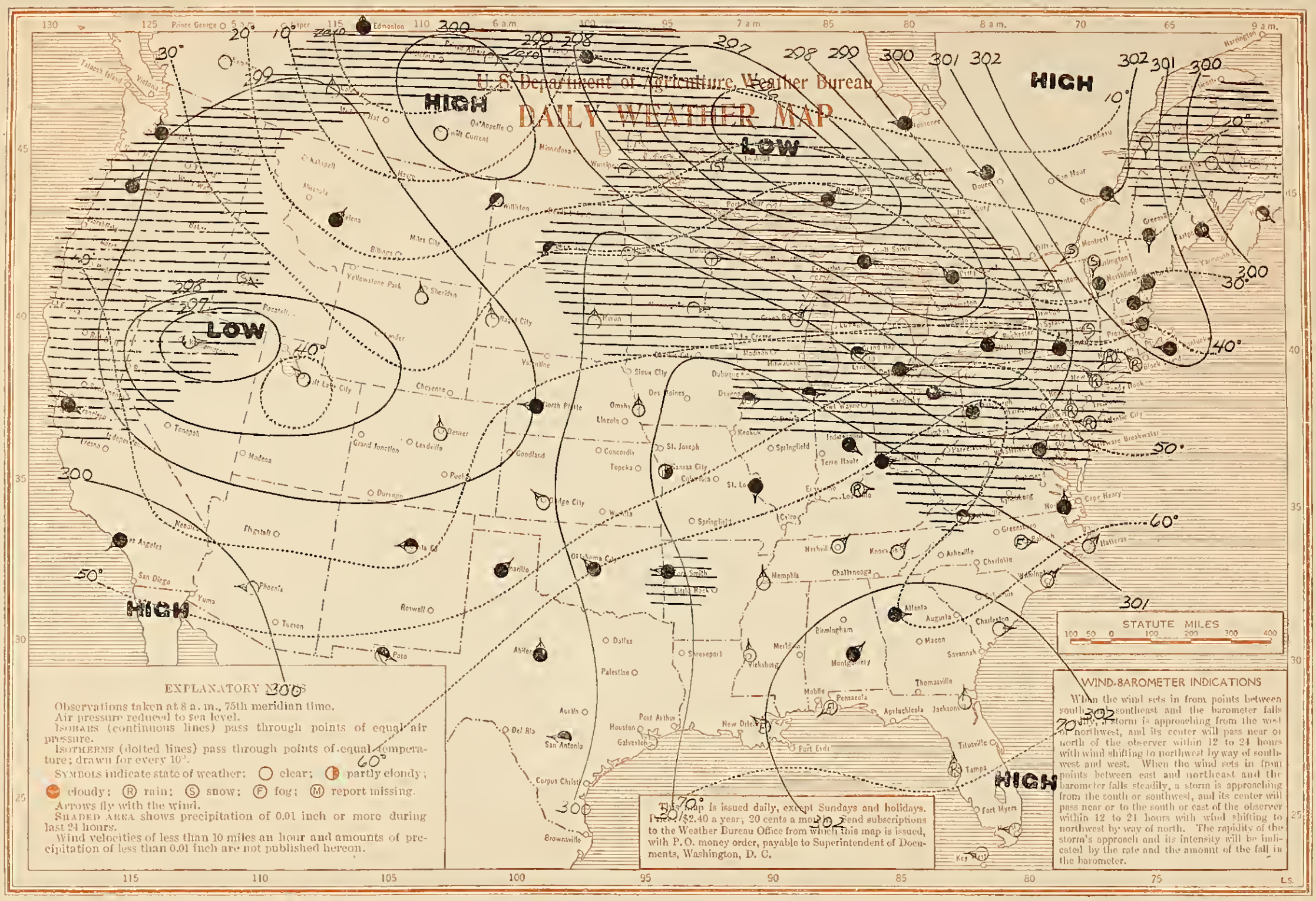
Total this month to date	0.69
Departure from normal	−1 59
Total since January 1st to date	10 08
Departure from normal	+0 82

Stations	Temperature At 8 a. m.	Highest last 24 hours.	Lowest last night.	Wind velocity 8 a. m. to-day.	Precipitation in last 24 hours.
Abilene, Tex	66	88	66	.....	0
Albany, N. Y.	44	44	36	.....	0
Amarillo, Tex	62	76	62	24	0
Atlanta, Ga	60	64	50	.....	0
Atlantic City, N. J	44	48	42	14	.01
Binghamton, N. Y	38	40	38	.....	.02
Bismarck, N. D.	34	64	34	14	.10
Block Island, R. I	40	44	36	12	.34
Boise, Idaho	34	62	32	.....	0
BOSTON, MASS	42	43	38	10	.07
Buffalo, N. Y	40	44	36	.....	0
Burlington, Vt	36	38	32	.....	.06
Calgary, Alberta	4	46	4	24	.06
Canton, N. Y	34	42	32	.....	.08
Charleston, S. C	60	64	66	.....	0
Chatham, N. B	32	38	24	.....	0
Chicago, Ill	40	66	40	10	0
Cincinnati, Ohio	50	64	48	.....	.02
Cleveland, Ohio	44	64	44	.....	.10
Cochrane, Ont	10	40	8	.....	.04
Concord, N. H	38	42	28	.....	0
Davenport, Iowa	44	58	42	12	0
Denver, Colo	40	50	40	30	0
Detroit, Mich.	38	66	38	.....	0
Dodge City, Kans	62	66	66	24	0
Doucet, Que	22	34	16	12	0
Duluth, Minn	32	42	30	12	0
Eastport, Me	34	40	32	.....	.20
Edmonton, Alberta	.....	.....	.....	.....	.....
El Paso, Tex	48	78	48	14	0
Father Point, Que	32	38	26	10	.04
Fort Churchill, Manit.	−22	.....	−22		0
Fort Smith, Ark.	70	76	66	10	0
Galveston, Tex.	66	74	66	16	0
Grand Rapids, Mich.	38	54	38	14	0
Green Bay, Wis	32	62	32	.....	0
Greenville, Me	34	40	26	...	0
Halifax, N. S	36	40	34	12	.60
Hatteras, N. C	64	68	64	.....	0
Helena, Mont	28	46	28	.....	0
Huron, S. Dak	42	64	40	14	0
Indianapolis, Ind	62	68	62	14	.01
Jacksonville, Fla	64	76	62	.....	0
Kamloops, B. C.	28	62	26	.....	0
Kansas City, Mo	64	62	50	.....	0
Key West, Fla	74	82	70	.....	0
Knoxville, Tenn	60	50	46	.....	.70
Louisville, Ky	66	68	54	.....	.10
Los Angeles, Calif	42	68	42	.....	.06

Stations	Temperature At 8 a. m.	Highest last 24 hours.	Lowest last night.	Wind velocity 8 a. m. to-day.	Precipitation in last 24 hours
Memphis, Tenn.	66	74	66	.....	0
Miami, Fla	66	78	62	.....	0
Minneapolis, Minn	40	50	38	14	0
Montgomery, Ala	66	78	62	.....	0
Montreal, Que	34	40	34	.....	.08
Moorhead, Minn	38	66	36	14	0
Moosonee, Ont	.....	.....	.....	.....	.....
Nantucket, Mass.	40	42	36	10	.26
Nashville, Tenn	66	68	64	10	.14
New Haven, Conn	44	44	38	.....	.30
New Orleans, La	70	80	70	.....	0
New York, N. Y	44	44	40	12	.24
Norfolk, Va.	66	64	66	.....	0
Northfield, Vt.	36	42	32	.....	.14
North Platte, Nebr.	46	66	46	.....	0
Oklahoma City, Okla	66	80	66	14	0
Omaha, Nebr	50	58	44	18	0
Parry Sound, Ont.	24	40	22	.....	0
Pensacola, Fla	64	70	64	12	0
Philadelphia, Pa	46	48	44	10	.06
Phœnix, Ariz.	40	68	38	.....	0
Pittsburgh, Pa	48	50	48	.....	.38
Portland, Me	38	42	34	.....	.10
Portland, Ore	36	46	36	12	.18
Prince Albert, Sask	18	20	14	.....	0
Quebec, Que	34	38	32	12	.02
Raleigh, N. C	66	68	66	.....	.22
Rapid City, S. Dak	44	66	42	14	0
Sable Island, N. S	36	36	32	18	.01
St. Louis, Mo	64	66	62	14	.10
Salt Lake City, Utah	32	42	32	.....	.48
San Antonio, Tex.	66	90	64	14	0
San Francisco, Calif	48	56	48	.....	.06
Santa Fe, N. Mex.	24	54	24	.....	.02
Sault Ste. Marie, Mich	24	40	20	.....	.02
Seattle, Wash	36	42	34	12	.04
Sheridan, Wyo	30	44	26	.....	0
Sioux Lookout, Ont	12	40	10	.....	0
Swift Current, Sask	26	48	26	16	0
Sydney, C.B.I.	32	34	26	.....	.04
Tampa, Fla	66	84	62	.....	0
The Pas, Manit	12	12	10	.....	0
Vicksburg, Miss	68	82	68	.....	0
Washington, D. C.	50	68	48	.....	.02
White River, Ont.	8	38	4	.....	0
Williston, N. Dak.	34	62	34	.....	0
Wilmington, N. C.	62	72	68	.....	0
Winnemucca, Nev	32	46	30	10	0
Winnipeg, Manit	34	38	16	16	0
Wytheville Va	62	62	46	.....	.30

Upper-air Observation above Boston

Elevation	Temp.	Rel. Humid.	Wind Dir.	Wind Vel.
2000 Feet	40	72	n.	28
4000 Feet	34	72	n.	68
6000 Feet	34	46	nw	22
8000 Feet	32	34	.....	.....
10000 Feet	24	28	.....	.....
14000 Feet	14	24	.....	.....



BOSTON, MASSACHUSETTS, THURSDAY, MARCH 21, 1935.

U. S. Post Office & Courthouse Building — Telephones { LIBerty, 5600, Extension, 389 to 391. (For aviation only) East Boston, 1808.

FORECAST TILL 8 P. M. FRIDAY

For Boston and Vicinity: Rain and slightly warmer this afternoon, becoming fair by evening; fair and warmer to-night, Friday fair and slightly colder; lowest temperature to-night in the lower 40's; moderate southeasterly winds, shifting to westerly to-night.

Massachusetts, Rhode Island, and Connecticut: Rain this afternoon, generally fair and warmer to-night; Friday fair and slightly colder.

Maine: Snow in interior, and snow or rain on the coast this afternoon and to-night; slightly warmer to-night; Friday fair.

New Hampshire and Vermont: Snow or rain this afternoon; generally fair to-night; Friday fair and colder.

Eastern New York: Fair to-night and Friday; somewhat warmer in extreme east, and slightly colder in extreme southwest portion to-night; colder Friday.

Atlantic Coast, Eastport to Sandy Hook: Moderate to fresh southeast and south winds, shifting to westerly by to-night over south portion, and increasing east or southeast becoming fresh, shifting to westerly to-night over north portion; and mostly overcast weather with rain or snow over north portion to-night; Friday fair.

For Shippers: Protect perishable shipments moving north and northeast for temperatures slightly below freezing, next 36 hours.

Weather Conditions

The northwestern disturbance has moved northeastward to Ontario, the lowest reading reported being 29.52 inches at White River. It has caused snow from the Dakotas eastward to the St. Lawrence Valley and northern New England, and rain thence southward through the Ohio Valley and Virginia, but none in the Western Plains States, where dust storms are still prevalent from Oklahoma northward over Kansas and Nebraska. A disturbance is apparently developing over the Middle Rocky Mountain Plateau, 29.70 inches at Salt Lake City. Temperatures have fallen slightly in New England and eastern New York, and risen thence westward over the Lake region and the Ohio Valley, and fallen again in the Western Plains States and the Northwest.

G. H. NOYES

Current Data

BOSTON, MASS	To-day 8 a.m.	Yesterday noon	Yesterday 8 p.m.
Barometer	30.12	.....	30.12
Temperature	40	54	51
Wind direction	e.	w.	nw
Wind velocity	5	12	20
Relative humidity	44	48	31
Precipitation in past 12 hours	0	....	0

Special Reports

Stations	Pressure	Temp.	Wind dir	Wind vel.	Weather
Boston Airport	30.13	38	e.	3	cloudy
St. Georges, Ber'nda	30.04	62	n.	12	cloudy
Deer Island Light	.....	40	n.	6	cloudy
* Mt. Wash. Summit	23.70	22	sw.	30	cloudy
North Truro	.....	36	e.	2	cloudy
Nantucket Shoals (Light Vessel)	30.07	42	calm	0	cloudy

* Elevation 6270 feet

Boston Temperature Data

Mean yesterday	49
Departure from normal	+12
Departure from normal this month to date	+74
Departure from normal since January 1st	−96

Boston Precipitation Data

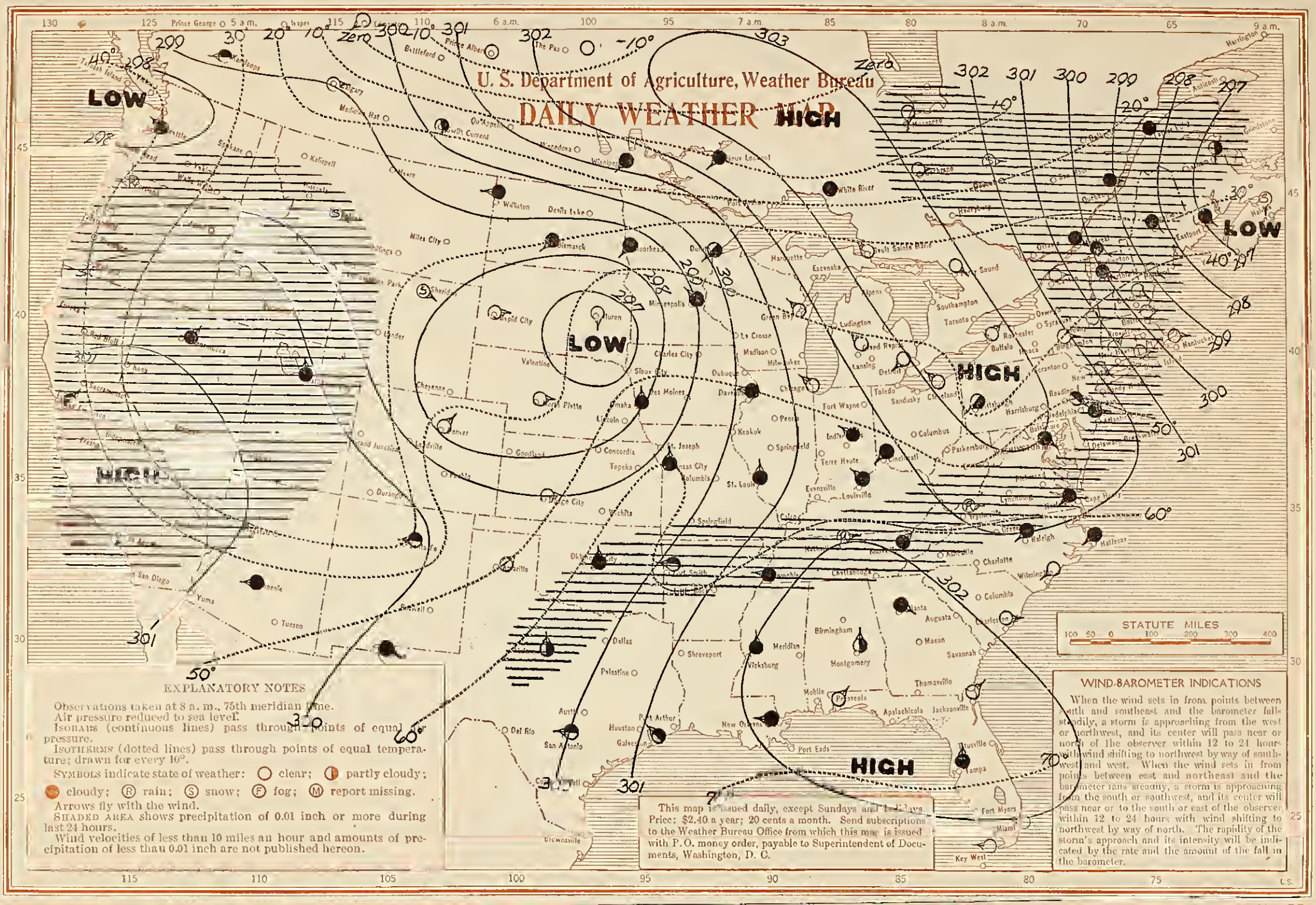
Total this month to date	0.69
Departure from normal	−1.72
Total since January 1st to date	10.08
Departure from normal	+0.69

Map DD

Stations	Temperature: At 8 a.m.	Highest last 24 hours	Lowest last night	Wind velocity 8 a.m. to-day	Precipitation in last 24 hours
Abilene, Tex	62	78	62	10	0
Albany, N. Y.	32	58	32	.....	.02
Amarillo, Tex	46	62	42	...	0
Atlanta, Ga	60	80	58	.....	0
Atlantic City, N. J	44	56	44	.....	.22
Binghamton, N. Y	46	54	38	.....	.38
Bismarck, N. D.	30	52	28	.....	.20
Block Island, R. I	40	52	38	14	0
Boise, Idaho	32	38	30	.....	.16
BOSTON, MASS	40	50	38	.....	0
Buffalo, N. Y	42	52	42	22	.34
Burlington, Vt	26	48	26	.. ..	0
Calgary, Alberta	6	8	2	10	.04
Canton, N. Y	28	48	28	20	.02
Charleston, S. C	66	82	62	.....	0
Chatham, N. B	26	42	20	.....	.01
Chicago, Ill	46	66	46	10	.96
Cincinnati, Ohio	50	68	58	.....	.54
Cleveland, Ohio	52	64	48	26	.36
Cochrane, Ont	20	28	18	18	.20
Concord, N. H	36	54	34	.....	0
Davenport, Iowa	44	68	44	.....	1.02
Denver, Colo	36	60	32	.....	0
Detroit, Mich	52	56	40	14	.32
Dodge City, Kans	44	64	44	10	0
Doucet, Que	16	26	2	.....	0
Duluth, Minn	34	36	32	18	.44
Eastport, Me	24	46	24	12	0
Edmonton, Alberta	−10	4	−10	.....	.01
El Paso, Tex	56	68	54	.....	0
Father Point, Que	16	38	14	.....	.02
Fort Churchill, Manit	2	.....	− 4	24	0
Fort Smith, Ark	62	78	62	.....	.04
Galveston, Tex	66	72	66	12	0
Grand Rapids, Mich	46	60	46	14	.20
Green Bay, Wis	38	52	38	14	.02
Greenville, Me	18	42	16	.....	0
Halifax, N. S	28	42	26	22	0
Hatteras, N. C	66	66	54	10	0
Helena, Mont	20	36	20	.....	0
Huron, S. Dak	34	52	34	.....	.34
Indianapolis, Ind	56	72	56	10	0
Jacksonville, Fla	66	88	64	.....	0
Kamloops, B. C.	22	44	20	.....	0
Kansas City, Mo	44	74	44	..	0
Key West, Fla	76	82	72	10	0
Knoxville, Tenn	62	78	62	.....	0
Louisville, Ky	60	78	60	10	0
Los Angeles, Calif	48	50	46	.....	0
Memphis, Tenn	66	80	66	.....	0
Miami, Fla	74	78	72	.....	0
Minneapolis, Minn	36	50	36	.....	.32
Montgomery, Ala	62	82	62	.....	0
Montreal, Que	24	46	24	.....	0
Moorhead, Minn	28	42	26	.....	.44
Moosonee, Ont	8	12	0	18	0
Nantucket, Mass	40	54	36	.....	0
Nashville, Tenn	68	82	68	.....	0
New Haven, Conn	42	62	42	.....	.04
New Orleans, La	68	82	68	.....	0
New York, N. Y	42	66	42	10	.24
Norfolk, Va.	54	58	50	10	0
Northfield, Vt.	28	46	28	.....	0
North Platte, Nebr.	44	62	40	.....	0
Oklahoma City, Okla	62	78	62	.....	0
Omaha, Nebr	48	70	48	12	0
Parry Sound, Ont.	32	42	32	16	.10
Pensacola, Fla	66	72	64	.....	0
Philadelphia, Pa	48	66	46	12	.24
Phœnix, Ariz.	42	66	42	.....	0
Pittsburgh, Pa	66	66	54	14	.42
Portland, Me	32	54	32	.....	0
Portland, Ore	36	44	36	.....	.18
Prince Albert, Sask	− 4	20	− 6	.....	.01
Quebec, Que	18	42	18	.....	0
Raleigh, N. C	58	70	56	.....	0
Rapid City, S. Dak	30	54	30	.....	0
Sable Island, N. S	30	38	30	28	.28
St. Louis, Mo	54	82	54	.....	0
Salt Lake City, Utah	42	48	40	18	0
San Antonio, Tex	68	84	68	12	0
San Francisco, Calif	44	56	44	.....	.24
Santa Fe, N. Mex	34	46	28	.....	0
Sault Ste. Marie, Mich	36	40	30	.....	.30
Seattle, Wash	36	48	36	.....	.02
Sheridan, Wyo	24	50	24	.....	0
Sioux Lookout, Ont	22	34	20	...	.08
Swift Current, Sask	2	26	2	.....	0
Sydney, C.B.I.	30	38	28	12	.30
Tampa, Fla	66	88	64	.....	0
The Pas, Manit	10	26	10	16	.10
Vicksburg, Miss	66	86	66	.....	0
Washington, D. C	56	64	52	.....	.08
White River, Ont.	34	34	24	16	.30
Williston, N. Dak	18	48	18	.....	0
Wilmington, N. C	62	76	58	.....	0
Winnemucca, Nev	32	48	32	.....	.01
Winnipeg, Manit	14	36	14	20	.36
Wytheville Va	60	62	48	10	.02

Upper-air Observation above Boston

Elevation	Temp.	Rel. Humid.	Wind Dir.	Wind Vel.
2000 Feet	34	54	s.	4
4000 Feet	38	42	w.	22
6000 Feet	32	46	w	22
8000 Feet	26	56	w.	24
10000 Feet	24	78	w.	20
14000 Feet	.....	.....	.....	.....



MAP-DD

BOSTON, MASSACHUSETTS, FRIDAY, MARCH 22, 1935

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FORECAST TILL 8 P. M. SATURDAY

For Boston and Vicinity: Fair, colder, with lowest temperature near or slightly under freezing to-night; Saturday becoming cloudy, probably showers late in the afternoon or at night; moderate northwest shifting to southeasterly winds.

Massachusetts, Rhode Island and Connecticut: Fair and colder to-night; Saturday cloudy with rain beginning Saturday afternoon or night.

Maine: Fair and colder to-night; Saturday increasing cloudiness, rain or snow Saturday night.

New Hampshire and Vermont: Fair and colder to-night; Saturday cloudy followed by rain or snow beginning Saturday afternoon or night.

Eastern New York: Fair, somewhat colder in southeast portion to-night; Saturday cloudy followed by occasional rain.

Atlantic Coast, Eastport to Sandy Hook: Diminishing northwest winds shifting to easterly Saturday and fair weather to-night, Saturday overcast with rain beginning Saturday afternoon or night.

For Shippers: Protect perishable shipments moving northwest, north, northeast from temperatures of 18° to 28°; elsewhere, 28° to 32°, next 24 hours; warmer Saturday night.

Weather Conditions

The disturbance that caused light snow or rain in western New York and New England in the last 24 hours has moved off the Nova Scotia coast, and is followed by rising pressure, with a ridge of near 30.30 inches extending from the Lake Region southeastward over the Ohio Valley accompanied by slightly lower temperature. The western disturbance has moved northeastward into South Dakota, 29.70 inches at Huron, causing unsettled conditions and rising temperatures in the Western Plains States. There have been showers and thunderstorms from Oklahoma eastward over Arkansas and Tennessee, and light snowfall in parts of the Northern Rocky Mountain States, but little precipitation elsewhere.

G. H. NOYES

Current Data

BOSTON, MASS	To-day 8 a.m.	Yesterday noon	Yesterday 8 p.m.
Barometer	29.91	.....	29.89
Temperature	43	35	36
Wind direction	w.	e.	nw
Wind velocity	20	12	8
Relative humidity	35	81	82
Precipitation in past 12 hours	0	.....	.01

Special Reports

Stations	Pressure	Temp.	Wind dir	Wind vel.	Weather
Boston Airport	29.95	44	w.	20	clear.
St. Georges, Ber'uda	30.02	66	w	20	cloudy.
Deer Island Light	.....	42	w.	24	clear
* Mt. Wash. Summit	23 28	10	w.	80	snow.
North Truro	.....	38	w.	18	clear.
Nantucket Shoals (Light Vessel)	29.94	42	w.	12	clear.

* Elevation 6270 feet

Boston Temperature Data

Mean yesterday	37
Departure from normal	0
Departure from normal this month to date	+74
Departure from normal since January 1st	−96

Boston Precipitation Data

Total this month to date	0.70
Departure from normal	−1 84
Total since January 1st to date	10 09
Departure from normal	+0 57

Stations	Temperature At 8 a.m.	Highest last 24 hours	Lowest last night	Wind velocity 8 a.m. to-day	Precipitation in last 24 hours
Abilene, Tex	62	80	62	.....	.02
Albany, N. Y.	44	48	42	12	.04
Amarillo, Tex	60	76	50	10	0
Atlanta, Ga	62	78	55	.....	0
Atlantic City, N. J	50	58	46	12	.04
Binghamton, N. Y	40	64	34	.....	0
Bismarck, N. D.	28	46	28	14	0
Block Island, R. I	44	44	36	24	.14
Boise, Idaho	26	40	26	.....	0
BOSTON, MASS	43	43	34	20	.01
Buffalo, N. Y	36	44	34	.....	0
Burlington, Vt	38	42	32	18	.06
Calgary, Alberta	12	34	12	.....	0
Canton, N. Y	38	40	32	12	.05
Charleston, S. C	68	92	62	.....	0
Chatham, N. B	26	40	20	.....	0
Chicago, Ill	48	64	42	.....	0
Cincinnati, Ohio	52	66	62	.....	0
Cleveland, Ohio	48	56	44	14	0
Cochrane, Ont	12	36	10	.....	.14
Concord, N. H	44	44	26	.....	.05
Davenport, Iowa	60	66	46	10	0
Denver, Colo	44	54	42	.....	0
Detroit, Mich.	38	64	34	.....	0
Dodge City, Kans	46	76	48	.....	0
Doucet, Que	12	32	12	12	.40
Duluth, Minn	34	46	34	18	0
Eastport, Me	34	38	30	12	0
Edmonton, Alberta	−8	16	−8	.....	0
El Paso, Tex	54	76	54	.....	0
Father Point, Que	24	28	20	.....	.02
Fort Churchill, Manit.	0	...	0	10	0
Fort Smith, Ark.	58	66	58	10	2.76
Galveston, Tex.	66	74	56	10	0
Grand Rapids, Mich	44	56	40	10	0
Green Bay, Wis	38	52	38	.....	0
Greenville, Me	26	32	24	18	.04
Halifax, N. S	30	38	30	.....	0
Hatteras, N. C	64	72	58	14	0
Helena, Mont	26	38	24	.....	.04
Huron, S. Dak	46	56	46	.....	0
Indianapolis, Ind	52	66	52	12	0
Jacksonville, Fla	68	88	66	.....	0
Kamloops, B. C.	32	44	30	.....	0
Kansas City, Mo	60	68	58	12	0
Key West, Fla	74	80	72	10	0
Knoxville, Tenn	60	84	60	.....	.74
Louisville, Ky	56	66	54	.....	0
Los Angeles, Calif	44	58	44	.....	.02
Memphis, Tenn.	52	72	58	.....	.66
Miami, Fla	74	78	72	.....	0
Minneapolis, Minn	48	54	46	14	0
Montgomery, Ala	62	86	62	.....	0
Montreal, Que	34	38	26	12	.02
Moorhead, Minn	34	40	32	12	0
Moosonee, Ont	8	20	6	.....	.24
Nantucket, Mass.	44	44	36	16	0
Nashville, Tenn.	62	72	60	.....	.30
New Haven, Conn	46	46	38	.....	.18
New Orleans, La	68	82	68	.....	0
New York, N. Y	48	54	48	22	.16
Norfolk, Va.	54	84	54	12	.20
Northfield, Vt.	38	46	28	18	.06
North Platte, Nebr.	34	68	34	.....	0
Oklahoma City, Okla	60	72	58	12	.08
Omaha, Nebr	56	68	54	14	0
Parry Sound, Ont.	32	42	28	.....	0
Pensacola, Fla	66	72	66	.....	0
Philadelphia, Pa	52	60	60	.....	0
Phœnix, Ariz.	46	72	46	.....	0
Pittsburgh, Pa	38	68	38	.....	0
Portland, Me	42	42	32	32	.02
Portland, Ore	38	46	38	.....	.08
Prince Albert, Sask	−12	12	−12	.....	0
Quebec, Que	28	28	24	18	.04
Raleigh, N. C	62	86	62	.....	0
Rapid City, S. Dak	32	62	32	10	0
Sable Island, N. S	32	34	30	12	0
St. Louis, Mo	56	68	56	10	0
Salt Lake City, Utah	30	62	30	.....	0
San Antonio, Tex	66	84	66	14	0
San Francisco, Calif	44	52	44	.....	.06
Santa Fe, N. Mex	30	54	30	.....	0
Sault Ste. Marie, Mich	30	46	28	.....	0
Seattle, Wash	40	48	38	.....	0
Sheridan, Wyo	34	60	32	.....	0
Sioux Lookout, Ont	10	34	0	.....	0
Swift Current, Sask	20	30	20	.....	0
Sydney, C.B.I.	28	34	22	.....	0
Tampa, Fla	68	86	64	.....	0
The Pas, Manit	−12	14	−12	.....	0
Vicksburg, Miss	66	82	64	.....	0
Washington, D. C.	62	80	52	.....	0
White River, Ont.	10	42	5	.....	0
Williston, N. Dak	28	38	26	.....	0
Wilmington, N. C	64	88	60	.....	0
Winnemucca, Nev	20	36	16	.....	.20
Winnipeg, Manit	12	20	10	.....	0
Wytheville Va	54	74	54	.....	.26

Upper-air Observation above Boston

Elevation	Temp.	Rel. Humid.	Wind Dir.	Wind Vel.
2000 Feet	40	38	nw	42
4000 Feet	30	36	nw	54
6000 Feet	28	28	.....	.....
8000 Feet	26	24	.....	.....
10000 Feet	24	22	.....	.....
14000 Feet	10	18	.....	.....

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